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Engineering News-Record

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Dropping key stones into the top of a rubble breakwater on the Great Lakes

Experience With Alternate Designs of Breakwaters on the Great Lakes

Lost Time In Construction—IV

Management Delays

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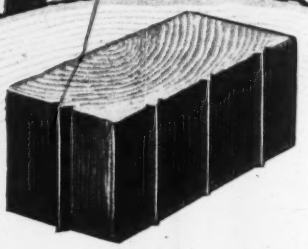

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ENGINEERING NEWS-RECORD

DEVOTED TO CIVIL ENGINEERING AND CONTRACTING

E. J. MEHREN *Editor*

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Lost Time Committee Action Urged

JOINT committee action by national associations of engineers and contractors is called for in this issue in the concluding article on lost time in construction. While *Engineering News-Record* is not committed to the precise plan outlined, it believes that organized action along the lines of inquiry which are indicated should be prompt and energetic. The waste from winter idleness and weather and management delays is a plain challenge of the efficiency of construction engineering which cannot be ignored.

The Search for Stability

THE prime functions of money are to provide a trustworthy standard of value and a stable medium of exchange. Both these are essential to trade, which, in turn, is so essential to the economic health of the world. When the paper symbols of money are perverted from those necessary and legitimate purposes to the endless creation of "capital" out of thin air, money becomes worthless for its true functions, and a substitute must be found. One of these is a reversion to barter. This remedy, however, is so clumsy and so limited in its application that for general use a more convenient one must be sought. Most satisfactory of all appears to be the use of a foreign currency of more stable worth. The growing conviction of the European peoples to the worthlessness of their own currencies is reflected by the increasing transaction of domestic business in terms of foreign coinage.

The Ultimate Issue

ISSUES of vast importance to American business are involved in the work that has been undertaken by the President's coal commission. In the first place, the findings of that body will go far toward determining whether the coal industry shall follow the railroads into the tangle of government regulation. The alternatives now lie before it. On the one hand, self-government for the industry and prosperity for operators and miners alike, provided only that the requisite wisdom and courage can be found in the industry itself. On the other, political regulation, with all its demoralizing handicaps, should short-sighted and selfish interests prevail. But a further responsibility, greater even than that of self-preservation, rests upon the coal industry. It must convince the commission of its capacity and its good faith for the sake of American business in general. The verdict in this case will, in the eyes of many, indicate whether we have reached the limit of private administrative ability. The transportation system of the country has passed almost beyond the pale of private management. Public utilities of every description are close behind it. Should the coal industry be forced to join them, how long would it be before others would follow the same road? As our civilization becomes more and more complex, more and more of our industry becomes of fundamental importance, and more and more of our business activities are woven into the very life of the community. And if American business genius should be adjudged incompetent to deal with these overhadowing problems on a business basis we may expect to see private enterprise increasingly replaced by public control Unless the coal industry can rise to its present responsibilities, the President's commission may yet become the thin edge of a wedge that would exert a far-reaching effect on American industry.

Courageous Beginning

IN TAKING up the thorny subject of building failures and how to prevent their recurrence, the New York section of the American Society of Civil Engineers has begun most courageously a long and hard task. Building failures do not arise from any one single cause, and no simple formula will solve the problem of eliminating them. Whatever the ultimate solution, moreover, a persistent campaign will be required to put it into effect. The task could easily have been evaded, since building failures rarely involve engineers and so do not constitute an obvious engineering responsibility. But a clear, courageous view of the situation was bound to reveal the underlying responsibility of the engineering profession for the structural safety of buildings—for their due strength and stability. And out of this responsibility springs a public obligation to correct faulty conditions, an obligation which rests primarily on structural engineers but in the last analysis on the undivided civil engineering profession, since after all this profession stands as a unit in its relation to the public. Frank recognition of this obligation was the motive that led to taking up the work of reform. So far the effort is local, and the magnitude of the work ahead is scarcely yet appreciated. In its progress, however, there will be occasion for engineers throughout the country to join with their New York colleagues; joint effort, vitalized by the spirit of discharging an obligation of professional honor, will make ultimate success assured.

Asphalt Varieties

IN LAST week's issue was concluded a discussion of a proposal made in *Engineering News-Record*, Sept. 28, to reduce the number of varieties of asphalt commonly specified for road and paving work. In the presentation of the case from the manufacturer's point of view it was asserted that non-uniformity in specifications and ultra-refinements in tests placed a needless burden upon the producers without resulting in any compensating advantages in improved construction. With this point of view federal, state, and city highway and paving officials seem to be in general accord. Nine representative engineers in the highway field expressed their opinions; of this number, one represented the federal government, three the state highway departments, four the city paving departments, and one an asphalt pro-

ducer. No one of the nine objected to the reduction in varieties of asphalt to seven grades (by the penetration test), while one went even further by suggesting five grades as being ample for all practical purposes. However, the opinion of those who discussed the subject was not merely negative, in most cases positive endorsement to the plan was given. While those who contributed to the discussion constitute only a small percentage of the country's asphalt users, they are all men of standing to whose opinions importance must be attached. If, therefore, the points made in the original article and endorsed in the discussion are sound, action along the lines indicated should be taken by our specification making organizations such as the American Association of State Highway Officials, American Society for Testing Materials, and American Society for Municipal Improvements. With the evidence available a decision should be reached.

The Dangerous Forties

SUMMER this year in most sections of the country is dying hard and the calendar and thermometer show a certain lack of teamwork. Just the same, frost is in the air and November coming on so the annual warning about cold weather concrete is due. Hammering on the dangers of cold weather concreting and emphasizing the effectiveness of precautionary methods has had its effect in the past few years and more and more contractors realize their responsibilities and capabilities in winter concrete work. The next two months are the critical ones, however. Definite freezing weather carries its own warning. It is when the mercury hovers between thirty and fifty that the bars are let down and it is in this snappy weather that concrete takes so long to set up and makes of itself a menace. Watch out for the concrete which is placed in the dangerous thirties and forties.

Spreading Pipe Purchases

JUDGED by the discussion which begins this week in the department, "From the Manufacturer's Point of View," water-works officials are in sympathy with the desire of cast-iron pipe manufacturers, expressed last week in this journal, to have purchases spread over the entire year instead of concentrated in the summer months. It is generally conceded that a substantial economic loss results from the present practice of seasonal buying of pipe, and that, to some degree at least, the peaks and valleys in the curve can be made less steep. Location and climate are important factors in winter work and practices which can readily be put into effect in the South become impossible under the conditions of a cold New England winter. Then, too, the matter of municipal financing and appropriations enters into the problem, and, while water-works departments might be willing to place their orders well in advance, such a course may be rendered impracticable due to delays beyond the control of water department officials, in making appropriations available. Valid as some of these objections are, there is no doubt that the producer and the consumer of pipe can co-operate more closely than they have done in the past and to mutual advantage. Customs, long followed, are often allowed to govern the conduct of work merely because they *are* customs and not always because the facts justify their continuance. The present discussion on winter purchase of pipe is useful, therefore, in bringing out statements of fact and opinion which may serve as a basis for desirable changes in practice where conditions make such change possible.

Sound Doctrine for Organized Labor

HARD upon his declaration of faith in the efficacy of direct negotiation between railroad employees and executives as opposed to political intervention, W. G. Lee, head of the trainmen, has announced the decentralization of the train-service brotherhoods in handling matters of strikes, wages and working rules. The trainmen and conductors will handle their business hereafter through regional groups; and Mr. Lee believes that under this plan he will be able to look after the interests of his men more effectively. He is right. Everyone knows that nation-wide labor combinations, organized without respect to regional or occupational lines, serve no economic purpose. They are strictly offensive weapons, calculated to overawe the community or, failing that, to beat it into subjection by brute force. Even in this respect they are treacherous weapons, for as Mr. Lee points out, an undiscriminating attack against the general welfare is too likely to arouse a community resistance, often difficult to overcome. By handling industrial controversies on their merits, with due regard to regional economic conditions, and with respect for the community welfare, organized labor stands a better chance in the long run of prevailing over the "hard-boiled" employer and of retaining the public respect while it is doing it.

Impulse Wheel Improvements

FOR MANY years no radical changes have been made in the design of impulse wheels. Great improvements have been made in details, in governors and in other auxiliary apparatus, but so far as general principles and fundamentals are concerned, one might conclude that this type of prime mover had reached its ultimate state. Such conclusions as to finality, however, are never safe. Elsewhere in this issue appears a note describing a new departure in the design of impulse wheels. Despite the recent trend to higher and higher heads on reaction wheels and the development of higher specific speeds for impulse wheels, there is still a field ranging between heads of 800 to 1,000 ft. to which neither impulse nor reaction type is exactly suited. That is, at these heads both types have certain disadvantages or limitations. In the attempt to apply the impulse wheel to the larger units toward which modern practice is tending, certain obstacles have not heretofore been overcome. The restriction of specific speed, more particularly, imposes on the large impulse unit a low angular velocity with the consequent heavier machinery and increased size of power house structure. On the other hand, the Pelton wheel has distinct advantages over the reaction type when the water contains sand or other impurities in considerable quantity, or when the unit is called upon to operate part of the time under partial load. In other words, the Pelton wheel has such advantages in resisting hydraulic wear and corrosion, and maintaining efficiency under varying loads that there is incentive to adapt this type to all heads. Considerable advance has been made in reaction wheel design in decreasing leakage through the clearance spaces around the runner and in prolonging the life of the seals, but

the impulse turbine does not have to meet the problem of leakage at all and hence no amount of improvement can put the reaction wheel on an equal footing with the impulse type so far as this feature of design is concerned. A closer approach to the ideal type of unit than anything yet available would be a runner having the hydraulic advantages of the impulse wheel and at the same time developing specific speeds approaching those obtainable with the reaction wheel. If and when the experiments referred to elsewhere in this issue lead, as the early results indicate, to the production of units in commercial sizes that fit these requirements, the whole field of hydraulic prime movers will be affected in a most beneficial way.

More Railway Work for Contractors

A FIELD for contract work which has been developed only to a relatively limited extent as yet, but which seems to give promise of considerable expansion in the next few years, is suggested by the article on another page dealing with the contracting of reconstruction and maintenance work on existing railway. This field is taken to include only the heavy class of work which is done ordinarily by railway floating gangs or extra gangs, but which is done more or less also by contract. It does not include the important but lighter work done by section gangs, since this appears to be more properly assigned to forces employed and controlled directly by the railways. In fact, recent attempts to introduce the contract system for this latter class of work have been the cause of unrest on the part of railway labor.

For the heavier work done by floating gangs, however, the conditions are different and appear to be becoming more and more favorable for the introduction of the contract system. This work is mainly seasonal so that new gangs must be built up and organized every year by the railway. A few of the skilled men may be regular employees, perhaps recruited from the shop or other permanent forces; but in general the gangs are composed of such outside men as can be picked up when required. Under such a condition the trouble and expense of organizing, training and maintaining a gang is likely to be disproportionate to the amount of work to be done. This situation may be improved materially if the railway can award the work to an experienced contractor, either by private contract or by competitive bidding.

Many railways have already employed the contract system in work of the class under consideration. It is true that opinions vary widely as to the desirability and success of this practice, but undoubtedly this is due in part to the fact that the contract work has been too scattered and too limited in the aggregate to develop the best methods of practice in handling and controlling it. With wider use and longer experience there will be a basis for the establishment of standard or uniform rules, specifications, contracts and means of control, thus conducing to higher efficiency and economy. Since the railways are being hampered increasingly by wage and working restrictions of their forces it seems highly probable that they may realize substantial advantages by adopting the contract system, particularly in reduction of labor problems and cost of work.

Special factors or conditions are involved in railway work of this class, notably as affecting the operation and safety of traffic. There is a strong and natural objection on the part of many railway officers to entrusting such work to outside interests. But as those conditions have already been met satisfactorily under the contract system they need not constitute a serious difficulty. It is essential, of course, to have the work done under close and continuous supervision and control of the railway officers, both as to quality and progress and as to possible interference with traffic. This is a matter of organization and control, however, which is one of the factors to be considered in drafting the contract.

To some extent this field is one for specialization. Some firms have already made railway improvement work a specialty but the field has barely been touched as yet and there is plenty of room for many others. Not every contractor is qualified or equipped to operate in this field. But as some contractors specialize in sewers, foundations, buildings or drainage work, so others may specialize in railway maintenance and improvement.

It is certain that the contract system at least merits special study and consideration by both the railway engineer and the contractor. The railway engineer may find a method of lightening his difficulties and reducing his expenses, while the contractor may find a wide expansion for his activities.

Successful Small-City Paving Practice

THE streets of small cities of 10,000 to 50,000 people offer one of the most difficult paving problems which engineers are called upon to solve. Such communities have a large mileage of streets per unit of population, they are in line with the main paved roads of state and country systems and, ordinarily, they possess only moderate funds for paving purposes. These are conditions which are difficult to harmonize.

With the people so generally owning automobiles the city engineer of the small city cannot as easily as he once could concentrate expenditures on a few main streets and give the other thoroughfares only superficial attention ordinarily, with perhaps a more thorough-going renovation every few years when complaint becomes insistent. Now, the car owners, who are on every street, are keen in demanding good surfaces and freedom from dust. Paving funds must be widely spread to meet this situation. On the other hand since the main streets of the town are links in county or state paved roads they are subjected to a heavier traffic than ever before and have to be kept in better shape to prevent adverse comparison with the state-maintained approaching roads. The facts stated complicate the city engineer's paving task, particularly if his funds, as is most generally the case, are limited. Successful solutions when they are found are, therefore, worth observing and one of them appears to be the development of tar treated gravel streets in Richmond, Ind., described in this issue. Apparently in this city about the cheapest of street surfacing is kept in excellent shape, smooth and dustless at a moderate annual expense. There is absolutely nothing new or radical in the methods. The work is simply well done and maintenance is meticulous. The last statement needs to be grasped completely because it is the key to success in keeping low class pavements fit to serve traffic. It is, too, the one requirement which the small-city street official most often fails to satisfy.

Experience with Breakwater Design on the Great Lakes

Types Include Rock Rubble-Mound, Mass Concrete and Concrete Caissons — Costs and Cross-Section — Quality and Requirements of Marine Concrete

IN BREAKWATER construction on the Great Lakes both stone-rubble and shaped concrete construction have been used extensively and successfully, but for both materials there are certain advantages and limitations, the selection in any one case being based on the cost and suitability under the conditions of that particular case or structure. An instance of this is afforded by the breakwater for the harbor at Great Lakes, Ill., which includes both rock rubble-mound and concrete-block construction, as described in *Engineering News-Record* of Dec. 29, 1921, p. 1069. Concrete was used on either side of the entrance in order to give practically uniform depth for the entire width of channel, while the slopes of a rubble mound would have required much greater width of opening. A review and comparison of some of the features of the two systems of construction is the purpose of this article, which is based on an extended inquiry.

It is of particular interest to note the opinion expressed by Maj.-Gen. W. M. Black (former Chief of Engineers, U. S. A.) to the effect that although breakwaters have

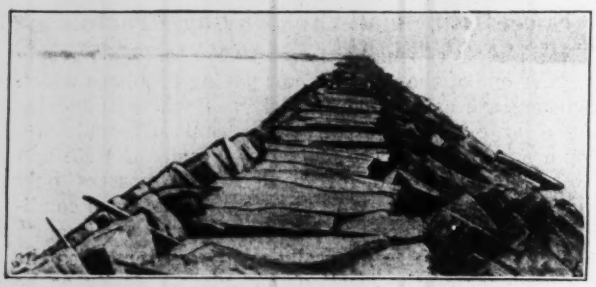

FIG. 1—ROCK RUBBLE-MOUND BREAKWATER AT ASHTABULA, OHIO.

been used for centuries, engineers have not yet fully adapted the design to the results required. He considers that through conservatism or lack of knowledge they have made these structures unduly expensive to build and maintain. Further, he points out that since the power of wave action is exerted most strongly for only a short distance below and above the water level, it is evident that economy of construction requires the minimum height which will afford the desired degree of shelter.

Rock Rubble-Mound Construction—Stone breakwaters are almost exclusively of the rubble-mound type, consisting of a base and core of small stone, faced and capped with massive rough quarry blocks to finish the structure to the required height and section. Care is required in placing the blocks so that they will interlock and support each other against the attacks of heavy waves, but repair work is required at times on account of damage done by storms. This construction for the outer breakwater at Chicago was described in *Engineering News* of Oct. 14, 1915, p. 740.

Typical rock rubble-mound breakwaters are those at Ashtabula and Conneaut, Ohio, shown in Figs. 1 and 2 respectively. Granite is usually considered the best stone for this purpose, as it absorbs very little water, is hard and does not disintegrate, while the rough and irregular shape of the blocks helps the interlocking of the mass of stone. Fig. 3 shows the placing of a massive keystone block in a breakwater of this type. The specifications of the Corps of Engineers, U. S. Army, for the work at Conneaut, Ohio, called for: "Hard, close-grained quarry run stone of quality suitable for the purpose and which will not disintegrate under the conditions to be met; its weight shall not be less than 135 lb. per cubic foot."

As an example of work of this kind the following particulars are given of the Conneaut breakwater,

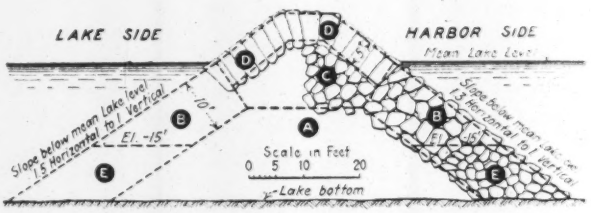

FIG. 2—RUBBLE-MOUND BREAKWATER AT CONNEAUT
A, quarry-run stone of any size; B, minimum 5 tons; C, minimum 500-lb., 50 per cent by weight to be 1-ton or more; D, minimum 3 tons; E, minimum 500 lb.

shown in Fig. 2, this information being summarized from the government specifications. Quarry run stone of any size is used for the lower part of the core, not more than 10 per cent of foreign matter being permitted. The upper part of the core is a mixture of such sizes as to insure dense construction, the minimum weight of stones being 500 lb. and 50 per cent by weight being 1 ton or more.

On the slopes of the core is a 10-ft. covering of heavier rock, with a minimum weight of 500 lb. in the lower portion and 3 tons up to lake level. The top of breakwater and upper parts of the slopes are formed with stones not less than 12-in. in least dimension and weighing about 3 tons, 10 per cent of less weight being permitted if properly interspersed with large stone. These large stones should extend at least 5 ft. into the work, perpendicular to the slope, but in not more than 10 per cent by weight this requirement may be reduced to 3½ ft. When the top of the breakwater is formed by stones weighing not less than five tons, a minimum thickness of 3 ft. is permitted. In the upper part of the core and the covering of the side slopes no stone is to be used whose greatest dimension is more than 3½ times its average thickness.

In construction, the lower part of the core and slope covering may be placed by dumping from deck or dump scows, derrick buckets or skips, or by tripping or lowering in place "or in any other manner which the contractor may select." Derricks must be used for the upper part of the covering, each stone being lowered in place before being released. For the top covering, all stones must be set securely and in as close contact with each other as practicable, with joints approximately normal to the surface of the breakwater. The maximum permissible variations from grade or between adjacent stones is 18 in. on slopes and 12 in. on top, measured at right angles to the surface.

One engineer of extended experience states that the rock rubble-mound is the best where the waterway is sufficiently large to permit its use, owing mainly to

ease of construction in exposed locations and the ease with which repairs can be made without disturbing the original work, together with the fact that any slight displacement or settlement is less apparent and unsightly than an equal movement in a concrete structure having straight lines and surfaces. Further, General Black considers that the rubble-mound has an advantage in the facility of changing the height and width of crest to meet conditions which may develop after construction has been started.

Concrete for Lake Marine Works—Concrete breakwaters and piers on the Great Lakes are of different types, approximately as follows: (1) Mass concrete, (2) poured or precast concrete blocks; (3) hollow reinforced-concrete caissons filled with stone or lean concrete and capped with concrete. In these three types the concrete work is mainly the superstructure, being placed upon a foundation bed of loose rock or upon timber cribs filled with rock. The caisson construction, as invented and patented by Col. W. V. Judson, Corps of Engineers, U. S. A., was described in *Engineering News* of Oct. 15, 1908, p. 419, 421, and in *Engineering News-Record* of Aug. 8, 1918, pp. 258 and 287. A typical caisson ready for launching is shown in Fig. 4. Concrete block rubble-mound construction, as used at some foreign ports, has been used very little by American engineers (except on the Panama Canal work) and not at all on the Great Lakes. Such work is not comparable directly with the stone rubble-mound, as its blocks are usually cubical instead of having the rough and irregular form of quarry blocks.

A theory advanced as to deterioration of concrete in marine work on the Great Lakes is that spray freezing upon the surface will build up great masses of ice and that when these are broken loose during a storm they carry small pieces of concrete with them. Also, that water will penetrate the surface and in freezing will split off small flakes, leaving a fresh surface for similar attack. It is obvious that deterioration from such causes must be very slow. Experience indicates that these effects are limited and that in general the injury is not cumulative. Investigations indicate also that actual abrasion of concrete by floating ice is very slight.

Climatic conditions are specially severe on Lake Superior, but concrete marine structures which have been in service for several years are reported officially to be in excellent condition. For example, it is stated that in the Marquette breakwater, built 1893-1905, there has been no deterioration of concrete where portland cement was used. In a portion of the work built with natural cement the surface disintegrated to some extent, but this occurred soon after construction and no change has occurred since. Further, at the piers of the Duluth ship canal, built in 1898-1902, there is no raveling, but the pier at Superior (1904-1913) shows some raveling at the water line. This action is attributed to the washing out of part of the cement by the motion of the water before the concrete had set thoroughly, which would produce a weak or lean surface concrete. But as the concrete back of this is of normal character the raveling is not expected to extend. In recent work means are taken to protect fresh concrete from wave action. These piers and the Marquette breakwater are shown in Fig. 5.

FIG. 3—PLACING KEYSTONE AND TOP BLOCKS OF RUBBLE-MOUND BREAKWATER

Quality of Concrete—That damage from ice and water may be reduced to a negligible factor if the concrete is made with a view to resisting these destructive influences is indicated in a report reviewing experience

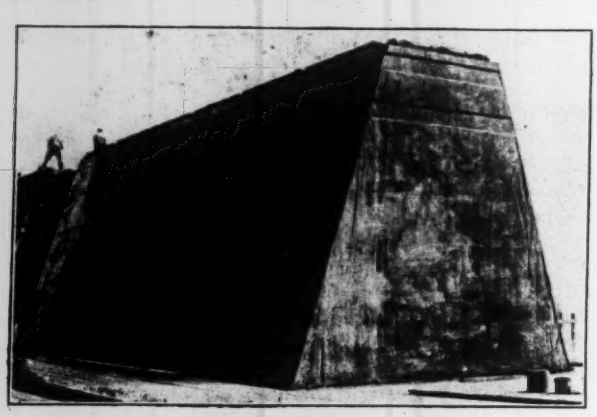

FIG. 4—CONCRETE CAISSON FOR BREAKWATER; READY FOR LAUNCHING

with concrete in breakwater and pier construction on Lake Michigan, by J. A. B. Tompkins, principal assistant engineer, U. S. Engineer Office, Milwaukee, Wis. An abstract of this is given below:

The first concrete construction in connection with works of harbor improvement on Lake Michigan was in 1888, when 95 ft. of concrete superstructure was built on the Chicago timber crib breakwater. The outer face of this concrete, which has been exposed to the elements for 32 years, is practically unaffected. The concrete superstructure on the timber crib breakwater at Milwaukee was begun in 1903 and completed in 1909. Quarry screenings were used instead of sand in this work, the proportions being 1:3:6 and 1:2½:5 for cement, screenings and broken stone. The screenings, or "stone dust" consisted of the product resulting from crushing limestone, all of which would pass through a screen with ¼-in. mesh and some was so fine as to pass through a No. 100 sieve. There is considerable disintergration of the superstructure in places, especially at the joints between monoliths. This may be due in part to movements of the timber cribs under heavy wave impact. In some places where superstructure blocks adjoin the damage extends for two or three feet into the blocks. The effect of the wear has been to form rounded surfaces which appear to have reached a sort of equilibrium, the annual damage being small. Such damage as has been done affects the appearance of the concrete more than anything else.

Reinforced-concrete caissons provided with concrete superstructure have been used at Algoma breakwater (1908), Manitowoc breakwaters (1909), Milwaukee south pier (1909-1910), Racine north breakwater (1912-1913), Sheboygan breakwater (1914-1915), Racine south breakwater (1916-1918), Indiana Harbor outer breakwater (1920). All caissons were of 1:2:4 mix, and generally "stone dust" was used instead of sand, the exceptions being that sand was used for the upper five feet of the caissons and for the entire superstructure for Racine south breakwater and entirely for the caissons for Indiana Harbor (see Figs. 4 and 6). At Algoma the outer surface of the caissons near the waterline has been worn to a depth of from an inch or two to six or eight inches. The rate of wear is very small and as there is 14 ft. of solid concrete behind the wearing surface, it may be safely said that the breakwater will last a hundred years, although its appearance is far from satisfactory. There has been less wear at Sheboygan, at Milwaukee south pier, and at Racine north breakwater, but apparently no wear at Racine south breakwater, which is in excellent condition. Many other concrete structures on Lake Michigan have well withstood the action of the elements.

While there are numerous examples on Lake Michigan where concrete made of "stone dust" has given excellent wear with little or no sign of disintegration, all concrete which has seriously disintegrated was made with "stone dust." Where well graded sand was used there has been practically no distintegration. Experiment has shown that concrete made with stone dust will absorb from 30 to 50 per cent more water than similar concrete made with sand. The use of stone dust or quarry screenings for making concrete, which will be exposed to freezing temperatures, is not recommended. The leaner the concrete, the greater the absorption, the percentages of absorption when sand is used being about as follows: 3¼ per cent for 1:1½:3 concrete; 5¼ per cent for 1:2:4; 6⅜ for 1:2½:5; 8⅜ for 1:3:6 and 9⅜ per cent for 1:5:10 concrete.

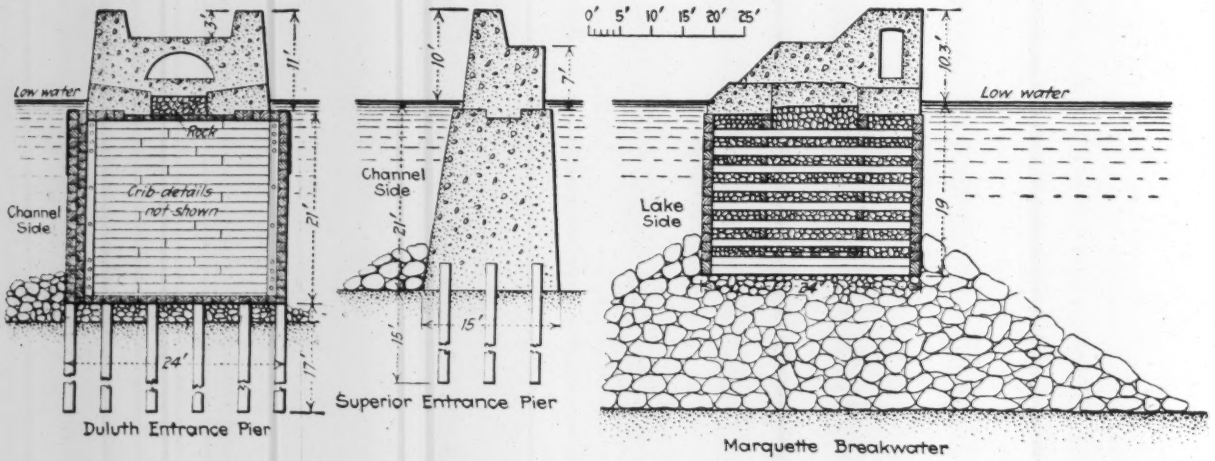

FIG. 5—EXAMPLES OF CONCRETE PIERS AND BREAKWATER

A careful inspection of all concrete harbor work on Lake Michigan leads to the confident belief that with mixes, aggregates and methods now employed no serious disintegration or wear by the elements need be apprehended. When wear has occurred, nothing is involved but the appearance of the structure and this can be restored, if desired, at relatively small cost.

Frost Effect on Concrete—An example of surface disintegration of concrete by frost is shown in Fig. 7, representing a portion of the north breakwater at Racine, Wis. This structure is composed of concrete caissons which are filled with rubble stone to within 3½ ft. of the top, this upper portion being filled with solid concrete. In this case the 1:2:4 mix was made with stone dust, and it has been pointed out above that

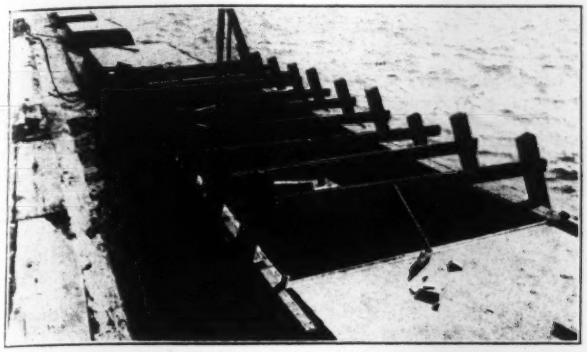

FIG. 6—BREAKWATER OF HOLLOW CONCRETE CAISSON BASE AT INDIANA HARBOR, IND.

such concrete absorbs more water and is thus liable to greater surface damage by freezing. High prices of sand are given as one reason for the use of stone dust.

Mr. Tompkins states that while the disintegration may extend to a depth of four or six inches in eight to ten years, beyond that depth the concrete is perfectly sound. In his opinion, the imperfections in the Racine breakwater are no greater or more serious than would exist in a rubble-mound breakwater after a similar length of exposure to wave action. Worse examples may be found, but the injury is usually local rather than general and being superficial the stability of the structure is not impaired or threatened. No repairs to concrete have been made on a large scale but small patch repairs are said to have stood for years.

Quality of Marine Concrete—High quality of concrete, both as to materials and manufacture, is of the utmost importance in marine structures. On this point, the following is an abstract of the report already mentioned, supplemented by a later statement from Mr. Tompkins:

The trouble with concrete, especially when used in marine construction is that its manufacture is not yet standardized, but experience indicates that with intelligent care at each step in manufacture a thoroughly durable concrete may be produced. Poor cement is not a probable cause of concrete failure, as cement manufacture has reached such a degree of excellence that it is rare to find cement which does not come up to the requirements of standard specifications. But the choice of aggregate is most important. Both stone and sand must be well graded and free from dirt. Our best results have been obtained by using a well-graded washed gravel with clean well-graded sand; but entirely satisfactory results have been obtained with crushed dolomitic limestone. "Stone dust" or quarry screenings should never be used in marine construction, at least above the frost line. No mixture leaner than 1:2:4 should be considered for marine construction, and a richer mixture is desirable if the concrete is to be deposited in water.

Mixing concrete with water polluted by sewage is frequently a cause of poor concrete, as evidenced by work at different localities. Where the water is relatively pure, the concrete is apparently of better quality than at localities where large amounts of sewage are discharged into the water. It certainly appears desirable to use as pure a water as may be economically attainable. The tendency has been to make entirely too wet a concrete. The proper water content should be ascertained and mechanical or other means taken to insure only the proper percentage of water in each batch.

It is of the utmost importance that concrete should be thoroughly mixed, and it has been found that with a ¾-yd. batch mixer at least twelve turns should be made after the materials have been charged. More turns and consequently longer mixing periods are advisable with larger mixers, but for ordinary work the use of rotary drum mixers of greater capacity than 1 yd. is not recommended. Much of the concrete on the Racine breakwater which has disintegrated (see Fig. 7) was made with a 2-yd. mixer. Contractors and foremen are usually in a hurry, and poorly mixed batches are sure to find their way into the mass unless the work is watched carefully and ample mixing is insisted upon.

Where concrete is to be deposited under water or even near the surface it is our present practice to use a canvas dam or curtain in the form. No attempt is made to deposit concrete in the dry, but the dam gives still water, free from waves and splashing which might wash out the cement. When this precaution has not been taken the result has been in some cases a honeycombed concrete subject to rapid deterioration.

Disintegration of concrete in marine construction is caused principally by the freezing of absorbed water, a contributing cause being erosion by floating ice. It is necessary, therefore, that concrete should be as dense as possible, with hard and fairly smooth surfaces. This requires that the sand and stone must be well graded and of proper quality, that the concrete is thoroughly mixed and that great care is taken in depositing it in the forms. Although the exposed surface should be hard and smooth, such special finish as is obtained in sidewalk work is not

FIG. 7—FROST AND ICE EFFECT ON CONCRETE BREAKWATER AT RACINE, WIS.

desirable. The surface should be made by working fine material to the outside, smoothing with a spade or other suitable tool, and taking care that no stone fragments extend through the surface skin, as all such places form points for the beginning of disintegration.

Cross Section a Design Factor—An advantage claimed for the rubble-mound breakwater is that it presents a combined sloping and irregular surface to absorb the shock and break up the solid mass of water in the waves, with the further and consequential advantage of reducing the reflex action due to the stoppage of the waves. In breakwaters of this type for the U.S. Government the outer slope is usually 0.66 on 1, or 1 on 1½. It is claimed that with smooth surfaces of the same inclination, the waves would shoot over into the protected area and cause undesirable disturbance. Stepped slopes might check such action by breaking up the solid body of the wave.

At certain places, however, such as harbor entrances, the flat slope would be undesirable on account of the great width of opening required for a channel of given

depth. This is instanced in the breakwater at Great Lakes, Ill., noted above. Concrete structures with such a flat slope for the full height are rarely if ever used and would require a greater cross-section than a structure with more nearly vertical sides and having equal resistive strength. In some cases the narrower structure is desirable or necessary, so that rubble-mound construction is not universally available. Concrete breakwaters have been made for some years with a face slope of about 3 on 1 for the body and a flatter slope for the superstructure, so that the waves generally flow over the breakwater.

It has been stated by General Black that if waves are to be excluded entirely from the sheltered area the breakwater must be high and of very heavy cross-section in order to kill the energy of the waves. In such case the energy is expended partly in throwing the water high into the air and partly in causing downward pressure and scour. If the breakwater is relatively low and with a flat slope, the wave will be tripped and the water thrown downward on and across the structure. This will cause a splash and slight disturbance in the sheltered area, but the wave energy will be dissipated. The rougher the resisting surface the more the energy of the wave will be broken up, but on the other hand the heavier must be the individual blocks and the better must they be bonded together.

Comparative Cost—Direct comparison of cost of stone and concrete construction is not easy, since conditions vary at different points. For the former it has been claimed that the cost of stone rubble-mound construction is less than that of concrete caisson work in shallow water and about equal to the latter in depths of 25 to 30 ft. An engineer who has used concrete extensively considers that the rubble-mound construction as designed by the U. S. Engineers may be cheaper in depths not exceeding 16 ft., but that in depths of 30 to 40 ft., for which breakwaters are now contemplated, the concrete caisson type will be much cheaper and will enable the breakwater to be built in much less time. He estimates that as a very general rule the cost of concrete caisson construction will vary as the depth, while that of stone rubble-mound construction will vary as the square of the depth. On behalf of stone, however, it is claimed that this rule may hold true for quantities but not for price, since the unit price per ton of rubble-mound construction decreases somewhat with the depth, partly on account of the use of a larger percentage of core stone which is of relatively low price, and partly on account of the reduced overhead expense due to the greater quantity. At Great Lakes, Ill., the average cost complete was estimated at $224.50 per lineal foot for the rock mound and $222.25 for the concrete caisson work.

Engineers to Control Forest Fires

The forest fire problem of Minnesota is to be studied by a commission of engineers appointed by Governor Preuss, in view of the frequent and extensive losses of property and life. Premature drainage of land, far in advance of agricultural requirements, with the result of lowering the water table and leaving dry peat bogs, is suggested as one factor in the fires that occur every few years. This suggestion is made by J. R. Stack, in the October *Bulletin* of the Minnesota Federation of Engineering Societies, at St. Paul.

Justifiable Highway Expenditures Determined by Traffic

Percentage of Expenditure for Railway Maintenance-of-Way Basis for Determining Expense Justified for Road Improvement

BY N. W. DOUGHERTY
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THERE is a popular fallacy, sponsored by many organizations and individuals, that no matter what the expenditure, it may be justified on the general basis that good roads pay for themselves. My object, in this paper, is to show that this is sometimes true and many times it is not true.

Is there a method by which expenditures may be shown to be justifiable or excessive? The answer is that there is no absolute method, and one may never be developed, but there is certainly some way of balancing one expenditure against another to the end that money may be expended where most needed.

The new federal highway law fixes the federal system at 7 per cent of the total road mileage. This means that in many states 93 per cent of the roads will have to be cared for by the counties and in all the states 93 per cent of the roads must be cared for by the counties and the state. With the appropriation now authorized, the 7 per cent program will not be completed, in many cases, during a period of fifteen years. There will be a large mileage of the federal-aid system that will have to wait until toward the end of the program. In the meantime the traffic must pass over the roads. It is, therefore, time to study well while we are at the beginning of the work. In most states, somewhere between 80 and 90 per cent of the roads will fall to county or township charge. The real problem then is going to be one for the counties and the townships rather than one for the state and nation.

Roads of One County—Let us consider a specific example. In Davidson County, Tenn., 25 per cent of the road mileage is waterbound macadam with carpet treatment, constructed and maintained by the county highway department. Approximately 7 per cent of the total mileage has been designated as state and federal-aid roads. The map shows the weighted average daily traffic for the year on a large number of the main roads. The thickness of the line is proportional to the total number of vehicles passing both ways and the numerals show the average daily traffic for the year.

By taking the average of the counts at adjacent stations and multiplying by the distance between stations, a rough approximation to the total vehicle mileage may be obtained. Counts were made on enough of the minor roads to get an estimate of the average traffic on each road. The total estimated vehicle mileage is as follows:

	Vehicle Miles
Roads on which count was made	77,230
Estimates on main roads where no count was made	7,430
Estimate on district roads	14,600
Total	99,260

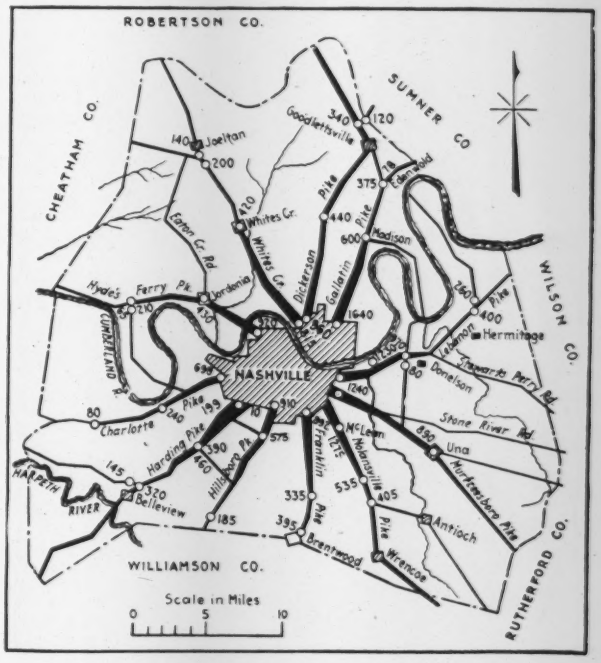
The main roads comprise approximately 25 per cent of the total mileage while the traffic on them comprises 85 per cent of the total traffic. The problem of economical expenditure is, therefore, with the 75 per cent of the mileage carrying the 15 per cent of the traffic.

The county's annual expenditure is about $420,000, or 1.16c. per vehicle mile. The average daily traffic varies from less than 25 vehicles per day to 2,000 vehicles per day. In the summer months the Harding Pike has a traffic of over 3,000 vehicles per day. If the average cost is 1.16c. and the traffic variation is so great, there must be a large range in individual costs. The County Highway Commission estimates that the main roads cost $750 per mile per year, exclusive of interest charge on original investment. Then 2,000 vehicles per day make a vehicle mile cost of 0.103c. 200 vehicles make a cost of 1.03c. and 20 vehicles make a cost of 10.3c. The expenditure on the district roads is less than $750 per mile per year. Half the above amount would give a vehicle mile cost of 5.1c. on the 20-vehicle roads. The investment in the main roads will average $6,000 to $8,000 per mile. If interest on this investment be charged as a part of the annual cost, the above amount should be increased by $300 to $400, making the vehicle mile costs increase accordingly.

Are Costs High or Low?—Is it possible to determine whether these costs are high or low? An approximate solution seems possible. In railway operation 20 per cent of the cost of operation is charged to maintenance of way and structures. In highway work the business of the highway departments is to furnish a traveled way with structures. It would, therefore, seem reasonable to assume that 20 per cent of the cost of operation would be a fair charge for highway costs. Few, if any, accurate costs of operation over the highways have been kept. The average cost of operating an auto or truck over the Davidson County roads will not be less than 10c. and it may be more than 15c. per vehicle mile, (83 per cent of the traffic in the county is motor traffic). Twenty per cent of 10c. is 2c. and 20 per cent of 15c. is 3c. Two to three cents per vehicle mile is not excessive because the public is paying two to five cents per vehicle mile on the toll roads in an adjacent county. If the charge were extortionate the toll roads would be avoided and use made of parallel, though less desirable, routes. This is not saying that the charge is what it should be, because the same or better service can be given for less than 2c. per vehicle mile. A service charge of between 5 and 10c. would be questionable and a charge of more than 10c. would probably drive much of the traffic off the roads.

In determining a fair vehicle-mile expenditure that a highway department may make, due consideration should be given to the saving in cost of operation due to improvement of surface. The difference will be greatest when the change is made from the mud to a hard surface and has been estimated to be as great as 10 to 15c. per ton-mile. The difference in the cost of operation for the various hard surfaces is not known. Engineers have usually assumed that it was not very great and have made their selections of type on other considerations. Suppose the life of a $2,000 automobile to be 100,000 miles, or 2c. per mile; now reduce this to 80,000 miles by a different type of surface and the cost will rise to 2.5c. per mile. Other costs would probably be increased accordingly. On the heavy traffic roads, where the unit traffic costs are low, this item may be the controlling factor in the selection.

Taking the 2 to 3c. as a reasonable vehicle mile expenditure, 2,000 vehicles per day would justify an annual expenditure of from $14,600 to $21,900 per mile; 200 vehicles per day would justify $1,460 to $2,190 per mile, and 20 vehicles per day would justify $146 to $219 per mile. Most of the main roads in the county have 200 or more vehicles per day throughout their whole lengths, which is enough traffic to justify a hard surface. Some of the district roads will have less than 20 vehicles per day, making it difficult to justify enough expenditure to furnish a hard surface. The county commission finds that it will cost about $500 per mile per



TRAFFIC DATA CHART FOR DAVIDSON COUNTY

year to furnish a macadam surface on the district roads. Now $500 per mile per year at 3c. per vehicle mile requires a traffic of 45 vehicles per day. There are probably 70 per cent of the roads in the county which average less than 45 vehicles per day. A larger expenditure than 3c. per vehicle mile must be justified or a smaller amount than $500 per mile per year expended.

Conclusions—It is thus seen that the total budget of $420,000 for this county may be justified, since the average cost is 1.16c. per vehicle mile, but it is doubtful whether all the expenditures on the district roads can be justified. Since the cost is so low on the main roads, the high cost on the district roads is apt to be overlooked. The traffic demands that a sufficient expenditure be made on the main roads. Where the traffic is over 200 vehicles per day, any surface necessary to carry the traffic may be justified, but only that type of surface should be chosen which will make the traffic costs a minimum. When the traffic is between 45 and 200 vehicles per day, enough money may be justified to furnish a surface that will carry the traffic, though the surface may not be of the highest class. When the traffic is less than 45 vehicles per day a high vehicle-mile cost will be necessary or the type of surface must be cheaper than waterbound macadam. It is with this class of road that the large saving in operating cost may come. Ten cents per vehicle mile on ten vehicles per day would justify an annual expenditure of $365. Such a sum can get the traffic out of the mud and place it on a dry surface paved, in many cases, with gravel.

Flow of Fluids Through Commercial Pipe Lines

BY ROBERT E. WILSON AND W. H. MCADAMS

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This analysis of fluid flow is a condensation of a much more extensive treatment of the same subject by the authors and M. Seltzer, published in the "Journal of Industrial and Engineering Chemistry," Feb., 1922. In that form it was known as "Contribution No. 40 from the Research Laboratory of Applied Chemistry, M. I. T." In the present form it is "Contribution No. 19 from the Department of Chemical Engineering, M. I. T."

THIS paper presents in condensed form the working method recommended by the authors for calculating the quantitative relations between pressure drop and rate of flow of fluids (gases, vapors and liquids) through commercial pipe lines. Those interested in the data from which the curves given were derived, and in a more detailed discussion of many of the more theoretical aspects, are referred to the more complete paper on this subject.

For many years engineers have used some form of the Fanning equation for this purpose. The form often used employs absolute units and is:

$$(1)\quad P = \frac{f w L v^2}{2 g m} = \frac{4 f w L v^2}{2 g d}$$

where P = pressure drop due to friction in lb. per sq.ft.
w = density of fluid in lb. per cu.ft.
L = length of straight pipe in feet.
v = average velocity of the fluid expressed as ft. per sec.
d = actual inside diameter of pipe in feet.
m = hydraulic radius in feet, namely, the cross-sectional area in sq.ft. divided by the wetted perimeter in feet.
g = acceleration of gravity = 32.2 ft. per sec.
f = a variable coefficient, called the "friction factor," *which has no dimensions.*

Usual Methods—In using this equation for a given fluid, engineers obtain the numerical value of the friction factor for the conditions in question from suitable tables or charts showing f as a function of certain variables. Thus, for the flow of air, f is often shown as an hyperbolic function of *diameter only*, as in the familiar Unwin' equation. There are some similar equations for steam, but practically no data for other gases, other than the complicated equation of Fritzche.[2] In the case of water, f is shown as a hyperbolic or other similar function of *both velocity and diameter*, and a factor of safety is introduced to allow for the formation of "tuberculations" or growths in the pipe. The variations of viscosity with temperature have been ignored, although they should not be. For the flow of oils having viscosities not widely different from that of water, f is sometimes corrected for viscosity, as well as for velocity and diameter, which necessitates a very complicated treatment.

It is found that empirical equations for f having fractional exponents of v and d can be derived, and the resultant equation combined with the Fanning equation. This is sometimes done, and thus the use of tables of f are avoided. To avoid the use of tables of logarithms for the fractional exponents, flow charts on logarithmic paper have come into vogue for air, water and steam, but no information is given as to their application to other fluids.

One great danger in using these exponential formulas and charts derived therefrom is that most of them were based on experimental data, were not in general highly accurate for a variety of reasons, and at best covered only a comparatively limited range of diameter, velocity and viscosity. Furthermore, use of complicated types of empirical equations for each different fluid has obscured the important fact that the flow of all fluids is essentially a single phenomenon, definitely predictable from the viscosity and density of the fluid in question.

Again, many engineers have not realized that with liquids of medium and high viscosity the flow, instead of being "turbulent" (such as is usually the case for air and water) may be "straight line" (or "viscous"), in which case the equation of flow is given by Poiseuille's law, which is quite different from equation (1). Even where this was known, it was not possible to calculate the relation between pressure drop and rate of flow for all fluids under all rates of flow; first, because there was considerable uncertainty as to which type of motion would prevail; and second, due to lack of reliable data for the numerical value of the friction factor for use in equation (1) when the motion is turbulent. Such data were desired, especially for the flow of oils of medium and high viscosity.

UNITS USED IN THE DIAGRAMS, FIGS. 1 TO 4

D = Actual inside diameter of pipe in inches.
f = Friction factor for the Fanning formula in the form of equations (1), (2) or (3). *The numerical value of f as taken from Fig. 1 may be used in any of the equations in this article, regardless of what units are used for the other terms in the pressure drop equations quoted.*
l = Length of straight pipe in feet, plus equivalent length (in feet) of elbows, etc.
p = Pressure drop as pounds per sq.in.
Q = Flow in U. S. gallons per minute.
s = Sp.gr. of fluid at its average temperature.
v = Average velocity of fluid in ft. per sec.
z = Viscosity of fluid at a definite temperature in "centipoises" (= viscosity relative to water at 68 deg. F.).

Basis of the Recommended Method—The following facts are now well established:

1. By using proper values of f equation (1) can be used for all fluids, regardless of the character of the motion.

2. The value of f in equation (1) for all types of motion is a function of velocity (v), diameter (d), density (w), and absolute viscosity (μ), and to a lesser extent of the surface roughness.

3. Fortunately, however, in pipes of similar roughness, f is not an *independent* function of each of these variables, but only of the ratio dvw/μ. *Therefore, in a given case on the numerical value of f of halving (or doubling) either velocity diameter, or density is the same as that of doubling (or halving) absolute viscosity.* Note: An inspection of equation (1) shows that f has no "dimensions." Hence, it should be a function of variables combined in such a fashion that the combination has no dimensions. From experiments, it was found that f varied with d, v, w, and μ. Taking these four variables in English absolute units, it is seen that the arrangement $\frac{dvw}{\mu}$ is the *only possible combination* in which the units cancel:

$$\frac{(d)\ (v)\ (w)}{(\mu)} = \frac{(ft.)\left(\frac{sec.}{ft.}\right)\left(\frac{lb.}{ft.^3}\right)}{\frac{(lb.)}{(sec.)\ \ (ft.)}}$$

4. *For straight line motion* in pipes of all materials, f is inversely proportional to dvw/μ, the proportionality constant being known, at least for very smooth tubes.

5. *For turbulent motion* in all kinds of pipe, the value of f is an *inverse* function of the ratio dvw/μ, but this function must be determined experimentally for pipes of varying degrees of roughness.

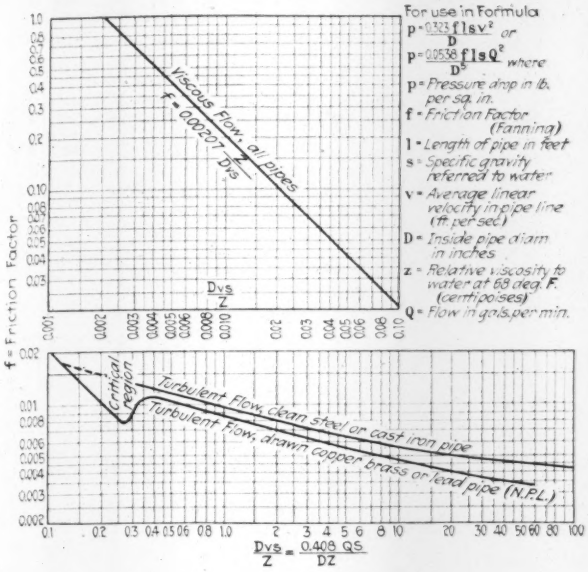
For use in Formula
$p = \frac{0.323 f l s v^2}{D}$ or
$p = \frac{0.0538 f l s Q^2}{D^5}$ where
p = Pressure drop in lb. per sq. in.
f = Friction Factor (Fanning)
l = Length of pipe in feet
s = Specific gravity referred to water
v = Average linear velocity in pipe line (ft per sec)
D = Inside pipe diam. in inches
z = Relative viscosity to water at 68 deg. F. (centipoises)
Q = Flow in gals. per min.
f = Friction Factor
Viscous Flow, all pipes
f = 0.00207 + 1/(Dvs/z)
Dvs/z
Critical region
Turbulent Flow, clean steel or cast iron pipe
Turbulent Flow, drawn copper, brass or lead pipe (N.P.L.)
Dvs/z = 0.408 QS/DZ

FIG. 1. RECOMMENDED FRICTION FACTORS (f) FOR COMMERCIAL PIPE LINES

These curves are based on the flow of air, steam, water and various oils in pipes of steel, wrought iron, lead, copper and brass. As compared with the very limited range covered by the ordinary tables of friction factors, the extreme range of diameter, velocity, viscosity, and density covered by the data used is very great, as is shown by the following:

Variable	Range
Inside diameter	Capillary tubes to 36-in. pipes
Velocity	0.1 to 100 ft. per sec.
Viscosity	0.02 to 3,000 times as viscous as water at 68° F.
Density	0.075 to 62.3 lb. per cu.ft.
Friction factor	0.003 to 6.0.

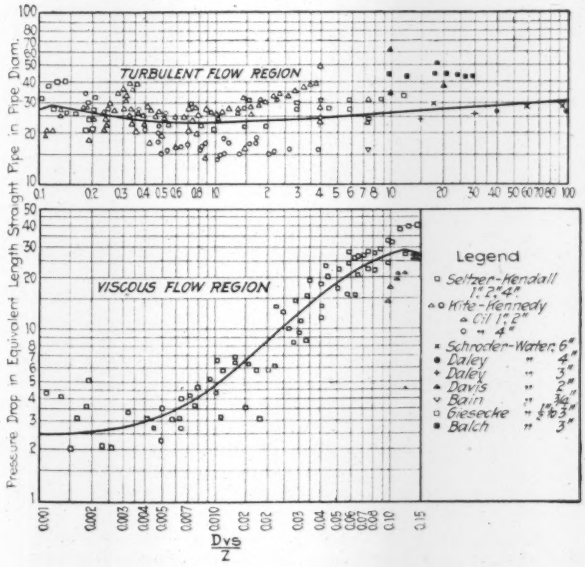

FIG. 2. ELBOW CONNECTIONS FOR COMMERCIAL PIPE

Balch, Univ. Wis. Bull., Eng. Series, 7, No. 3, p. 253.
Giesecke, Univ. Tex. Bull., Oct. 20, 1917.
Daly, Schoder and Bain, Cornell Civ. Eng., 20, p. 107 (1911-12).
Davis, Univ. Wis. Bull., Eng. Series, 6, No. 4, p. 115.

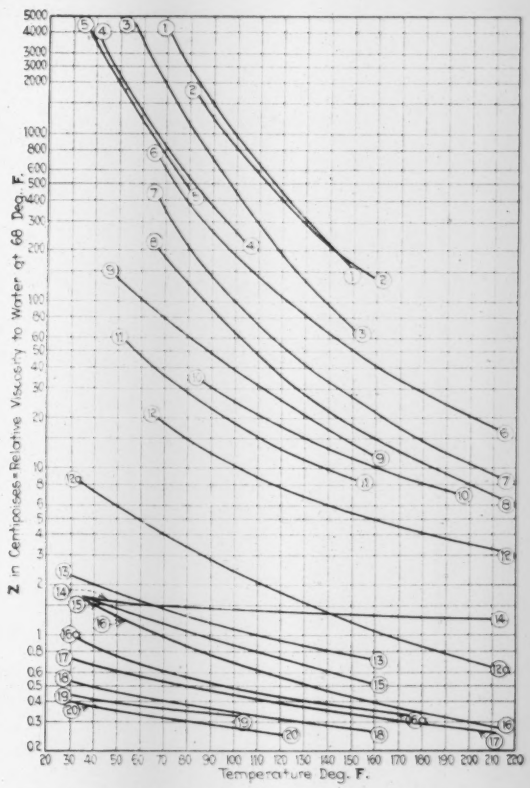

FIG. 3. TEMPERATURE VISCOSITY CURVES FOR TYPICAL LIQUIDS

1. Mexican petroleum (Mex. Pet. Co.).
2. Meprolene (Parks-Cramer Co.).
3. California heavy crude, 15.2° Bé. (Standard Oil Co.).
4. Castor oil (Smithsonian Tables).
5. Glycerol (Smithsonian Tables).
6. Mobiloil B (Vacuum Oil Co.).
7. Mobiloil A (Vacuum Oil Co.).
8. Texas engine oil (Vacuum Oil Co.).
9. Olive oil (Smithsonian Tables).
10. Linseed oil (Smithsonian Tables).
11. Cal. Light Crude, 24.4° Bé. (Standard Oil Co.).
12. Nonviscous Neutral (Vacuum Oil Co.).
12A. Amyl alcohol (Opt. inactive) (Smithsonian Tables).
13. Mercury (Smithsonian Tables).
14. Turpentine (Smithsonian Tables).
15. Ethyl alcohol (Smithsonian Tables).
16. Water (Smithsonian Tables).
16A. Benzene (Smithsonian Tables).
17. Octane (Smithsonian Tables).
18. Heptane (Smithsonian Tables).
19. Carbon disulphide (Smithsonian Tables).
20. Hexane (Smithsonian Tables).

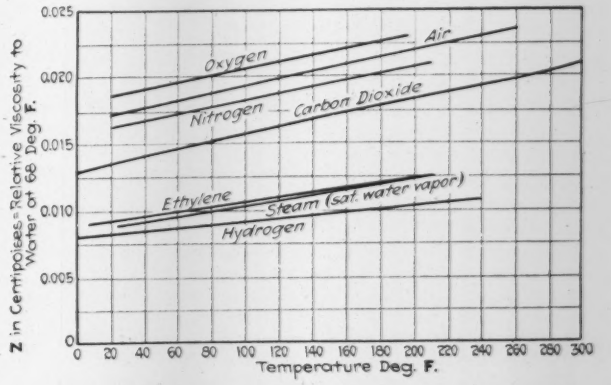

FIG. 4. TEMPERATURE VISCOSITY CURVES FOR GASES

Some or all of these facts were predicted long ago by several writers[3] who presented highly mathematical papers on this subject. However, their significance has not been appreciated by engineers, nor have they been verified experimentally over any considerable range of velocities and pipe sizes, until very recently. In 1912 Blausius[4] gave a good review of the theory, recalculated the data of Saph and Schoder[5] for water in *smooth* brass and galvanized-iron pipes and the data of Nusselt[6] for compressed air, and showed that f was a function of dvw/μ, *as required by theory.* This paper seems to have been almost completely overlooked outside of Germany.

In 1914 Stanton and Pannell[7] published the results of experiments made by them with air and water flowing in *smooth* tubes of drawn copper and brass, ranging in size from 0.713 to 12.62 cm. This work substantiated the prediction that for both types of motion, f is a function of dvw/μ, and they presented a chart showing numerical values of f for an equation similar to equation (1), employing c.g.s. units. In 1916 the National Physical Laboratory published additional[8] data for air and water, and a little for shale oil, again using tubes of drawn copper and brass. In 1920 the Kinney Mfg. Co. of Boston issued a pamphlet[9] based on the N.P.L. data for smooth pipes, using different units, and Preston[10] published a paper summarizing their results.

Several years ago the Research Laboratory of Applied Chemistry at the Massachusetts Institute of Technology began a series of experiments using primarily liquids of high viscosity in *commercial steel pipe* with the purpose of filling in the gaps in the existing data for pipes of a commercial degree of roughness. (For details of experiments, see Contribution No. 40, etc., mentioned in sub-title to this article.) The results of these experiments, together with those obtained by recalculating the available reliable data of many experiments (on water, oil, steam, air, etc.) made elsewhere, form the basis of the recommended curves (Fig. 1) for f as a function of the other variables.

As noted above, the value of the friction factor (f) in the Fanning equation can be calculated in the usual manner from experimental observations on drop in pressure, length of pipe, density of fluid, average velocity of fluid, and diameter of pipe. It has been pointed out that f for both types of motion should be a function of four variables grouped as dwv/μ.

For the practical application of the recommended method of treatment the authors find it desirable to make use of convenient engineering units, rather than absolute English units, on which the discussion has thus far been used. This is especially true in the case of viscosity, where the absolute units, pounds per second per foot (or its equivalent, second poundals per square foot) are difficult to visualize. The accompanying table gives the units used in all charts.

Since the above changes were made in the units for the variables determining the friction factor, similar changes were made in those units appearing in equation (1) and the form equivalent to (1) using the new units is as follows:

$$p = \frac{0.323\ flsv^2}{D} \qquad (2)$$

Sometimes it is more convenient to use discharge in gallons per minute (Q) instead of velocity in ft. per sec., giving

$$p = \frac{0.0538\ fls\ Q^2}{D^5} \qquad (3)$$

where s = specific gravity.
z = absolute viscosity in centipoises (= relative to water at 68° F.)
D = actual pipe diameter in inches.

The upper line in Fig. 1 is recommended for use for the flow of all fluids in "commercially smooth" pipes, such as standard steel pipe, while the lower line applies to "very smooth" pipes, such as drawn brass, copper or lead pipes, or glass tubes. Obviously, values still higher than those given by the upper line must be used for corroded or tuberculated pipes, or conduits lined with pebbles, or those with linings which appear quite rough to the naked eye. As shown in the more complete paper on this subject, the ordinary hydraulic data are quite discordant for reasons which are readily explainable; however, the widely quoted values of f for "clean cast iron pipe" taken from the Fanning tables check fairly well with the recommended line.

Recommended Methods of Calculation—A. General Procedure for Calculating Pressure Drop in Any Pipe Line: With the data and charts previously presented the calculation of the pressure drop through a pipe line under any specified set of conditions is a very simple matter. The steps involved may be outlined as follows:

1. Calculate the value of Dvs/z for the fluid and pipe in question.

2. By referring to Fig. 1, find the value of f which corresponds to this value of Dvs/z, using the curve corresponding to the degree of roughness of the pipe in question.

3. Usuing the same value of Dvs/z refer to Fig. 2 for the equivalent length of straight pipe corresponding to each 90 deg. elbow. Multiply this by the number of elbows, convert the correction from pipe diameters into feet, and add to it the length of *straight* pipe. (Note that two elbows very close together, or a return bend, have less effect than two elbows some distance apart.)

4. Insert this value of f in the modified Fanning equation ($p = \frac{0.323\ flsv^2}{D}$) and obtain the pressure drop directly. *This method and this formula should be used regardless of whether the liquid is in viscous or turbulent motion.*

B. General Procedure for Calculating Other Quantities: The foregoing procedure must, of course, be slightly modified in case the permissible or available pressure drop is known and it is desired to calculate any one of the other five quantities which may be unknown in a given practical problem. This requries only simple rearrangements of the equations and the use of the trial and error methods which are obvious to any engineer, though they are discussed more in detail in the original article.

C. Auxiliary Data (Elbow Losses, Viscosity and Specific Gravity. 1. Elbow Losses. Fig. 2 shows experimental values obtained mostly in this laboratory, for the "equivalent length" of standard 90 deg. elbows plotted against Dvs/z, and it is seen that the equivalent length averages about 30 diameters in the turbulent range (i.e., for values of Dvs/z greater than 0.12), while for lesser values of Dvs/z in the viscous flow region, the equivalent length decreases, finally reaching a value little greater than the *actual* length of the elbow.

2. Viscosity: For use throughout this paper viscosity (z) is expressed in centipoises—which may be more readily visualized as the viscosity relative to water at 68 deg. F., at which temperature water has a viscosity of one centipoise. Data in the literature are frequently expressed in poises and these results should be multiplied by 100 to give the viscosity in centipoises.

For many definite chemical compounds entirely satisfactory viscosity data are available in the literature, and data for a number of these and for some commercial oils are presented graphically in Fig. 3. For most commercial purposes, however, it is desirable to make an independent determination of the viscosity of the fluid. To determine this directly in absolute units is difficult and time consuming, but it is possible, for liquids that are distinctly more viscous than water, to employ one of the standard instruments familiar in the oil trade, such as the Saybolt viscosimeter, which measures the time of efflux of a given volume of liquid. A chart for converting these observed times into true viscosity in centipoises is given in the more extended article and elsewhere.

Since the same method of calculation is applicable to most problems involving the flow of gases, data are also appended (Fig. 4) for the viscosity of a number of common gases, including steam. It will be noted that whereas the viscosity of liquids decreases rapidly with increase in temperature, the viscosity of gases *increases.* It is also important to remember that the viscosity of gases is practically independent of the *pressure*, though of course the lat-

ter factor does affect the density, s, in direct proportion, and hence changes the value of Dvs/z, as would be expected.

3. Specific Gravity: The value of the specific gravity, s, should be expressed in units relative to water at 39 deg. F—in other words, it is equivalent to the true density in grams per cubic centimeter.

To convert true Baumé readings to specific gravity use the formula $s = \frac{140}{130 + Bé}$ for liquids lighter than water.

The density of liquids is usually known with fair accuracy, and the density of gases can be calculated with sufficient accuracy for practically all purposes by using the formula $s = \frac{0.001496\ p_a\ M}{t + 460}$ where M is the molecular weight, t the temperature in degrees F., and p_a the *absolute* pressure in lb. per sq.in. In dealing with gases, care should be taken to use an *average* value if the pressure drop through the line is enough to cause appreciable variations in the density.

D. Limitations of the Recommended Method of Calculation: The data and methods of calculation given in this article cover substantially the entire field of the flow of all fluids, including gases and dry vapors, through commercial pipe lines. There are, however, a few exceptions which should be carefully noted before attempting to use the formula in certain special cases. These may be noted as follows:

1. The method is not directly applicable to the flow of gases where the drop in pressure along the pipe line is more than 10 per cent or 15 per cent of the final *absolute* pressure, because the density and velocity of the fluid is thereby changed. If, however, *average* values are used for the density and velocity, instead of the initial or final values, this formula may be used for pressure drops up to 40 or 50 per cent without serious error.

2. The method is not applicable to flow through short sections of pipe opening into large chambers where the entrance and exit losses are appreciable in comparison with the friction losses through the pipe. These losses become inappreciable when the pipe is more than 1,000 diameters long, and may generally be neglected for approximate calculations for lines longer than 300 diameters. For shorter tubes the reader is referred to the recent comprehensive treatment of Herschel.[11]

3. The method is not applicable to the flow of semi-solid plastic materials, such as asphalt, clay suspensions, very viscous, colloidal solutions, etc., where the laws of flow are modified by the tendency of the material to behave like a solid under certain conditions.

4. Precautions must be observed, and highly accurate results cannot be expected in cases: (a) where the pipe is badly corroded or tuberculated, and the apparent value of f may increase to double that given in the formula, due partly to a decrease in the effective cross-sectional area; (b) where a hot oil is passing through a pipe line in *straight line* flow, and the existence of a large temperature gradient from the inside to the outside makes accurate calculations practically impossible; and (c) where there is any tendency to precipitate out solids (such as paraffin wax) on the walls or in the bottom of the pipe lines.

With these exceptions it is believed that the recommended method of calculation is applicable with an entirely satisfactory degree of accuracy to all commercial problems involving the flow of fluids through pipe lines.

Illustrative Calculations—To illustrate the practical utilization of the foregoing charts and tables, a typical example (calculation of required pressure drop) follows:

Example: It is desired to transmit 20 U. S. gal. per min. (686 oil bbl. of 42 U. S. gal. each per 24 hr.) of a very viscous oil at 70 deg. F. through a standard 6-in. steel pipe line. What will be the pressure drop as lb. per sq.in. per mile?

Data: The oil at 70 deg. F. has a time of 9,050 sec. in a Saybolt Universal viscosimeter and a gravity corresponding to 15.2 deg. Bé.

Solution: Using any convenient table of pipe diameters, one sees that $D = 6.07$ and $D^2 = 36.78$.

Since the average velocity $= \frac{0.408\ Q}{D^2}$

$$v = \frac{0.408 \times 20}{36.78} = 0.222 \text{ ft. per sec.}$$

From a viscosity conversion chart it is seen that the value of z/s, corresponding to a time of 9,050 Saybolt seconds, is 1,990.

Hence the numerical value of $\frac{Dvs}{z} = \frac{607 \times 0.222}{1{,}990} =$ 0.000677 and the value of f corresponding (Fig. 1) is 3.06 (extrapolation made by multiplying ordinates and dividing abscissae scales by 10).

The specific gravity at 70 deg. F. $= \frac{140}{130 + 15.2} = 0.964.$

The value of p is figured from the modified Fanning equation

$$p = \frac{0.323\ f\ l\ s\ v^2}{D}$$

$$= \frac{0.323 \times 3.06 \times 5{,}280 \times 0.964 \times (0.222)^2}{6.07}$$

$$= 40.8 \text{ lb. per sq.in.}$$

Thus it is found that this oil flowing at an average velocity of 0.222 ft. per second gives a pressure drop of 41 lb. per sq.in. per mile.

Acknowledgment—In conclusion the writers desire to repeat in briefer form their acknowledgment of the helpful assistance of Drs. W. K. Lewis and W. H. Herschel, and Messrs. Seltzer, Kendall, Kite, Kennedy, and Danforth; and also of the co-operation and financial assistance furnished by the National Tube Co., the Hammel Oil Burning Equipment Co., the Parks-Cramer Co., and The Texas Company.

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Forest Products Tests Reach Half Million

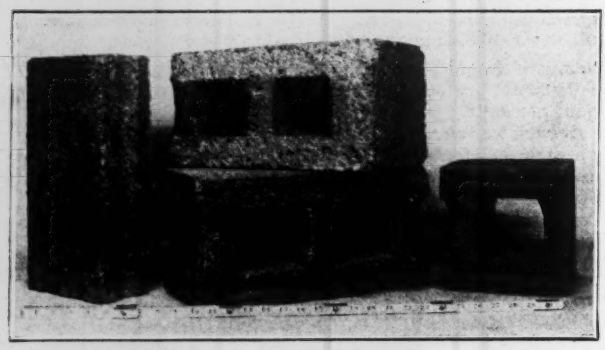
More than half a million tests of the mechanical properties of native wood have been carried out at the Forest Products Laboratory, Madison, Wis., in the 12 years since the work was initiated. Specimen 500,000 was of white ash grown in Bennington County, Vermont, and it was broken by impact with a 100-lb. hammer. The insert shows the felling of the white ash tree from which the specimen was taken with other test pieces needed in a study of the influence of growth conditions on the properties of wood, now in progress at the laboratory. The markings of the particular specimen shown indicate that it came from the south side of the tree, at a distance of 2 in. from the center, and between 12 and 16 ft. above the stump. The care used in marking this piece is typical of the care with which all specimens are marked in order to relate test data with growth conditions.

Fire Tests Favorable to Cinder Concrete Block

Underwriters Laboratories Report that the Straub Block Has Exceptional Structural and Fire-Resisting Qualities

AS A result of a series of fire tests made last summer, the Underwriters Laboratories has issued a report favorable to the structural and fire-resisting qualities of the cinder concrete block made under a license of F. J. Straub of New Kensington, Pa., the holder of U. S. patent No. 1,212,840. These blocks are made in the usual block machines in standard 8 x 8 x 16-in. and 8 x 8 x 8-in. hollow shapes and standard 4 x 8 x 16-in. and 8 x 8 x 16-in. solid shapes of a mixture of one part portland cement and six parts crushed cinders. The 8 x 8 x 16-in. hollow shapes weigh about 32 lb. each.

The tests made were the standard fire tests conducted by the Underwriters Laboratories; that is, a straight



TYPICAL CINDER CONCRETE BLOCKS USED IN TEST

fire exposure of 3 hr. 42 min. on a 10x11-ft. panel, a fire and hose stream test on the wall after being subjected to fire test for 1 hr., impact test of the panel, and absorption and compression tests of the individual blocks.

In the description of the test block the report reads:

The cinders which were stated to be ordinary run-of-boiler product resulting from the more or less complete burning of soft coal were a mixture of material of varying grades of fineness ranging from dust that would pass a 100-mesh sieve to pieces that would just pass a ¾-in. screen. Approximately 40 per cent by weight passed a 20-mesh screen. The presence of a considerable amount of unburned carbon was apparent on visual examination. Chemical analysis showed the presence of sulphur amounting to about 0.7 per cent of the dry weight of the cinders and of coal and coke amounting to between 18 and 19 per cent.

The 700 blocks examined in the Chicago freight house after shipment from York, Pa., were undamaged except in minor particulars. The blocks were of a dull slate gray color and of a rough pitted texture characteristic of lean cinder concrete. (See view.) The particles of cinder aggregate appeared to be completely covered by the cement. Rough handling of the dry blocks caused the separation of small particles from the surfaces, but no ordinary rough usage caused breakage. Nails were driven into the blocks without difficulty and without causing spalling, chipping, or cracking.

As a result of the tests, the report makes the following conclusions:

Fire Retardant Properties—Straub cinder concrete blocks constructed of the materials and by the methods described in this report, can be employed for the construction of exterior or interior walls, bearing or non-bearing, which when exposed to fire on either side will prevent the passage of flame through the walls and function as a barrier to the spread of fire by heat conduction for at least 2½ hours. Application of a hose stream to either side of the wall during the first hour of fire exposure will not seriously impair its fire resistance.

No flame passage occurred during the fire endurance test and no through openings were found. The critical temperature of 300 deg. F. was reached on the unexposed face at 2 hr. 58 min.

Practicability—The blocks may be shipped in bulk without material injury. They may be handled without difficulty and installed rapidly by any competent bricklayer using ordinary tools. Each of the two 10 x 11-ft. test walls erected in the laboratories was completed in about 2½ hours.

Durability—The blocks are capable of withstanding long-continued exposure to weather conditions without material deviation.

Specimen blocks were subjected to rather extensive series of tests involving saturation, freezing, thawing and drying. No visible deterioration was caused by any of these tests. Compression tests made on blocks subjected five times to saturation, freezing and thawing, and then three times to saturation, and drying, showed an average crushing strength of 750 lb. per square inch and a minimum of 580 lb. per square inch of the gross sectional area. These valves may be compared with the average of 815 lb. per square inch and the minimum of 650 lb. per square inch the case of blocks that had not been saturated. It is believed that these differences are not significant in view of the characteristic variations in compressive strength commonly shown by tests of concrete products.

Strength—The strength of the blocks is sufficient to warrent their use in bearing or non-bearing walls, within the limitations commonly recognized as applying to materials of this character.

In general concrete blocks are considered suitable only for buildings of moderate height and with types of floor construction and of occupancy that will impose loads on the walk well within safe limits for Straub blocks.

It is believed that there are not thus far any generally accepted specifications regarding the crushing strength of cinder concrete blocks. The building code recommended by the National Board of Fire Underwriters states that the average compressive strength for concrete blocks when tested with the cells vertical, shall be not less than 800 lb. per sqare inch. The blocks forming the subject of this report had an average crushing strength of 815 lb. per square inch.

The effects of the impact test were purely local.

Uniformity—The blocks can be produced commercially with the degree of uniformity sufficient for the purposes for which the material is intended.

The dimensions of the blocks are determined by the dimensions of the forms in which they are cast. The density and the compressive strength are subjected to variation within rather wide limits. In the case of the blocks employed in the examinations and tests described in this report, all being the product of the same plant, examination of 12 blocks showed weights varying from 16 to 25 per cent. Compression tests showed ultimate crushing strength varying from 650 to 1,140 lb. per square inch of gross sectional area. The cinders employed in the mixing of the concrete were of rather inferior grade with 18 to 19 per cent combustible material, the presence of unburned coal or coke being evident on visual examination. Approximately 40 per cent by weight of the cinders passed a 20-mesh sieve. The results of the tests made on the blocks employing this inferior aggregate and a rather small proportion of cement, were so favorable, notwithstanding the variation in some important properties, as to justify the opinion that the variations noted are within permissible limits.

Cleaning a Mixing Conduit of Lime Deposits

Hard Material in Mixing Conduits of St. Louis Plant Disc Harrowed Then Removed by Flushing Into Settling Basins

By C. M. Daily

Engineer in Charge, Supply and Purifying Section, Water Division, St. Louis, Mo.

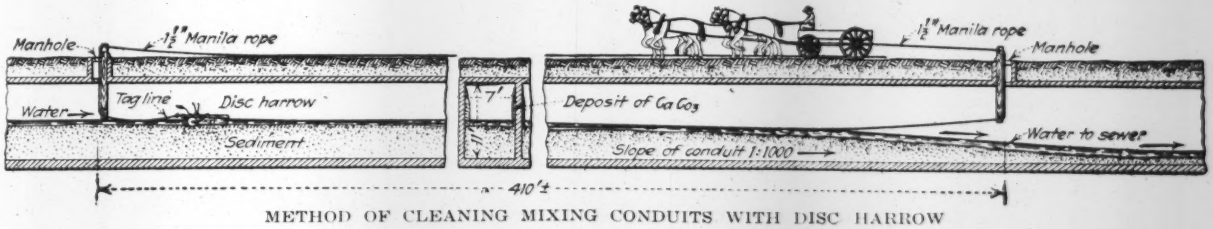
HARD deposits of calcium carbonate in the long mixing conduits of the St. Louis water purification plant were removed in April by disc harrowing and flushing after seven years' operation. The Water Department commenced to use lime and sulphate of iron for clarifying the water in 1904. Milk of lime and a solution of iron were first added to the water in the tunnel before reaching the pumps; but on account of lime deposits in the pumps and discharge pipes the point of application was changed to the outlet of the delivery well.

In 1915 a grit chamber and mixing conduit were built. The grit chamber has a cross-sectional area of over 800 sq. ft. and the velocity of the water through it is less than 0.3 ft. per second for a period of 7.4 minutes, which allows all of the heavy particles that will not pass through a 200-mesh sieve to deposit in its hopper bottoms. The water passes from the grit chamber into the mixing conduits, where milk of lime is now added. The mixing conduit of four compartments, rectangular in section, each 7 ft. wide, 11 ft. high and 2,388 ft. long, are arranged to operate in series or in parallel as desired.

A few months after putting the conduit in service an inspection was made and the west section was found to contain 2 ft. of soft mud on the bottom and a small amount of lime deposit on the sides. The accumulation on the bottom did not increase much in depth but the deposit of calcium carbonate on the side increased and after attaining a thickness of 6 to 12 in. would fall from the sides in heaps and remain undisturbed by the flowing water. This condition continued into the two western sections, which had been operated in parallel for the past two years, until last April, when the depth of the deposit was 5½ ft. on the north end of the west section and 4½ ft. at the north end of the adjacent one; the depth at the south end of both sections was about 3 ft. The surface of the bottom was very uneven, especially near the north end where heavy deposits fell from the side walls. The material was cemented together to such an extent that it could not be shoveled without first loosening it with a pick. The other sections contained only 18 in. of soft deposit on the bottom and very little on the side walls.

Cleaning Methods—The two western sections were taken out of service last April and the work of cleaning was commenced. About 200 ft. of the north end of the west section was cleaned by hand. The material was loosened with picks so that it could be shoveled into wheel barrows, in which it was wheeled to an opening at the north end, hoisted by means of a steam derrick, dumped into wagons and hauled away. This hand work was expensive and the next 150 ft. was cleaned by shoveling the material into water jets discharging into one of the settling basins, which was cleaned later by the usual method of flushing and scraping.

While this work was going on experiments were made in flushing and loosening the material by playing a hose on it, by men working with shovels stationed 15 to 20 ft. apart and by plowing. All of these methods were effective, as the water flowing 6 to 12 in. deep washed the loose material away. For loosening the material by plowing a disc harrow was employed. The tonnage was removed, runners were placed in front and the harrow was pulled through the conduit by teams on top, by means of a rope passing over pulleys arranged in frames at each end of a 410-ft. division of the conduit, the teams traveling in the opposite direction to that of the harrow. A tag-line on the harrow served as the pulling line on the return trip. Two men rode the harrow and adjusted the discs to suit the character of the material encountered. The flushing water was maintained at a depth of 12 in., flowing perhaps 4 ft. per second, which was sufficient to transport the material to the 24-in. sewer at the south end of the conduit. The work was begun at the south end and each division was harrowed until the depth of the deposit was reduced to about 9 in. when the next division was treated in like manner. Both sections were cleaned by this method except the 350-ft. stretch at the north end of the west section which was cleaned by hand. It is doubtful if the harrow would have been effective on the material encountered there owing to its hardness. About 380 cu.yd. of material was removed by hand at a cost of $2,199, and 2,870 cu.yd. by flushing and harrowing at a cost of $1,201. The amount of water used for flushing is estimated at 10,000,000 gal., costing $124.



METHOD OF CLEANING MIXING CONDUITS WITH DISC HARROW

Distribution of War Surplus Material

Every effort is being made by Senator Townsend, of Michigan, to prevail upon the Committee on Military Affairs to report favorably his bill providing for the distribution among the states of surplus war material so that Congress can pass the measure without delay. The plan of distribution provided in the bill would give to the states surplus material valued at $1,000,000,000 on the basis of population, and it would cost the states practically nothing. The Military Affairs Committee has had the bill before it since April 20, but, up to this time, has failed to make a report.

Lost Time in Construction—4

Management Delays

Interruption of Operations—Poor Utilization of Time Worked—Plant Delays—Service Delays—Delays Due to Poor Direction

By **C. S. Hill**
Associate Editor, Engineering News-Record

Fourth of a Series of Four Articles

IN ENUMERATING the causes of lost time in construction, brevity is gained by grouping a number of the lesser causes under the heading "management." Such a classification is arbitrary, because in a broad sense all lost time is due to industrial mismanagement. Planning the operation; scheduling progress; selecting, operating and maintaining equipment; directing the supply of materials; directing employment; standardizing practices; controlling costs and performance; and developing organization morale and proficiency constitute management as it is here assumed to be a cause of lost time.

It has to be made clear at the beginning that lost time, as it may be involved in the procedures named, is due (1) to interruption of operations and (2) to poor utilization of the time worked. A plant breakdown, for example, interrupts operations while poor plant co-ordination reduces the output in a unit of time. Time is wasted as effectually by inefficient methods or plant as it is by actual interruption of work, but there is a marked distinction between the two causes. Correction in the first instance puts more "days worked" into a year, while in the second, the "days worked" are merely better utilized. The distinction being made, lost time due to actual interruptions, will be considered first.

Management Delays Characterized—Lost time due to management is the cumulative result of many small delays. In the aggregate it is comparable with the time lost through winter idleness and by rain and mud delays. A schedule of the various kinds of management delays helps to make the situation plain. It is as follows:

1. Plant Delays:
   (a) Interruption of operations by plant breakdowns; (b) time lost shifting plant units on the job; (c) time lost waiting for other parts of the plant.
2. Service Delays:
   (a) Engineering restrictions on the kinds of materials that may be employed; (b) failure by producers to make deliveries as required; (c) inadequate railroad transportation facilities.
3. Labor Delays:
   (a) Interruption of operations by (1) strikes and (2) accidents; (b) seasonal unemployment.
4. Delays of Direction:
   (a) Faulty construction practices; (b) inadequate planning of operations; (c) poor engineering co-ordination and co-operation; (d) poor contracting direction.

This schedule is by no means exhaustive. It, however, includes the leading kinds of delays in the class being considered which interrupt construction operations and all that can well be considered in the space limits of an article.

Plant Delays—Plant delays—machine breakdowns, moving equipment and waiting by one unit for another—are commonly assumed to be greater than they really are. Of the 35 per cent lost time on highway work in Iowa in 1921 plant delays of all kinds contributed only 3.65 per cent and most of this was time lost shifting equipment on the job.

Persistent improvement of equipment design in recent years has done much to decrease the frequency of breakdowns. Most machines now produced by the larger manufacturers show remarkable improvement compared with practice even five years ago in simplicity, workmanship and materials and general sturdiness of design. It is common knowledge of those who know the manufacturers thoughts that this advance would have been greater except for commercial considerations. It has been impossible to put into general equipment the quality demanded for the most economic and reliable service and produce it at a price that contractors generally were wiling to pay. It is almost the first task, therefore, in reducing plant delays to

> 1. Express the worth of quality in equipment design and construction in terms of increased service so that contractors may have undisputed evidence that extra strength and durability is worth the greater cost.

Manufacturers generally have done less toward standardizing equipment than they have toward improving its quality. This is natural. The whole practice of machine design has been in a state of flux. Within limits, it is also wise. Any effort at standardization which might discourage invention and improvement would be disastrous to progress. On the other hand, it would be quite possible and certainly advantageous to standardize on sizes or capacities. An excellent example is the work done by the Mixer Manufacturers Association in settling on a few commercial sizes of concrete mixers and adopting a rule for expressing size. The second method of seeking to reduce plant delays follows:

> 2. Determine the limits and methods of possible standardization of construction equipment to facilitate repairs and to reduce the danger of mistakes in operation.

Machine breakdowns, or shutdowns for repairs, are a direct function of plant selection, operation and maintenance. If well built, sturdy machines are selected, if they are handled by skilled operators and if the maintenance is good, experience has shown that breakdowns will be a rare occurrence. The inference is obvious.

> 3. On any plant operation of magnitude a competent mechanical superintendent is required.

With all the mechanical care that can be given equipment, however, accidents will occur and operations will be interrupted particularly if the machine which breaks down is a link in a chain of equipment required for a single construction process as for example, would be the pump supplying water to a concrete roadbuilding outfit. In case of equipment breakdown, lost time is reduced:

1. By having a stock of replacement parts and a repair car or repair truck outfit ready to restore the machine to working condition.

2. By having duplicate plant, or important plant units, which can be thrown into service the moment failure occurs.

These are not extravagant precautions. In digging the Culebra cut of the Panama Canal machine shops mounted on cars were highly profitable in keeping the big fleet of steam shovels in repair. One western road contractor always has an extra paving mixer where he can swing it into action in an hour or two in case of a bad breakdown of the regular paver, and his pumps for water supply are installed in duplicate. A large concrete building contractor of Chicago commonly installs twin materials handling, mixing and hoisting outfits, each designed for considerable overload, so that if one unit breaks down the other can be speeded up and nearly maintain the normal output.

While individual contractors are doing these things and finding it profitable contractors generally are not. The reason is that the first cost of the extra units looms so large in their vision that they cannot see the loss due to frequent machine breakdowns. Naturally some of the precautions, such as the duplication of plant, are practicable only when the operation is large (and they are always more profitable on large operations), but others of them are practicable and profitable on any operation where mechanical devices control production. There are enough data in the possession of contractors to prove this assertion beyond dispute and they should be collected and analyzed.

The moving of equipment is a fruitful cause of lost time in some operations and amounts to little in others. Except for shifting forms and chutes the ordinary concrete building operation is often carried through without change in plant location. In concrete roadbuilding, on the contrary, some of the units are continually on the move and others have to be shifted every few miles of completed road. Mobile equipment, generally, has been highly developed and all the contractor has to do is to exercise intelligence in equipping himself with it.

It is the class of equipment ordinarily defined as portable or semi-portable that has to be considered most carefully. The shifting of derricks and hoists, of bins and conveyors, is a serious interruption to construction on many operations. In Iowa road work in 1921 moving plant accounted for 2.56 per cent of the total 35 per cent lost time and was the largest item of lost time except delays due to rain and mud.

A determination of methods of shifting various sorts of equipment and the designing of equipment which can be easily knocked down and re-erected require attention. More particularly statistics need to be presented of the time required for and the cost of shifting plant so that contractors may see the importance of planning carefully.

1. To decrease the number of shifts and

2. To conduct the necessary shifts as quickly and cheaply as possible.

Poor plant co-ordination causes lost time chiefly because the units of larger capacity have to wait for the units of smaller capacity to deliver their product. An example is furnished by steam shovel operation where there are not enough trains to remove the earth as fast as the shovel can excavate and load it and the shovel idles between trains. Such a condition is perhaps more truly a poor use of working time than it is an actual loss of time but it is by any measure a waste of time.

Service Delays—Delays in serving construction operations with materials, supplies and equipment may be a greater cause of lost time than any other thing. For example in building concrete roads in Illinois in 1920, with 100 paving outfits in service there were never more than 50 in operation at the same time because the railways could not deliver the materials. In other instances producers cannot provide the materials wanted in the quantities required when and where they are needed.

The principal reasons for the inability at times of the railways and the producers to serve construction may be stated as follows:

1. The demand for service is confined largely to the summer construction season and during that period is very large.

2. Construction materials are considered low-classification and non-preferential freight both by the railways and by railway regulatory bodies.

3. Local products and perishable and seasonal freights receive preferential consideration as a matter of business expediency. For the same reason producers supply first the permanent market provided by the local dealers.

Other reasons can be thought of but all reasons are unimportant compared with seasonal demand and the classification of construction materials as non-preferential freight. These are the conditions which have to be altered or other means of supply and transportation have to be developed.

Very little has been accomplished toward co-ordinating production, transportation facilities and demand to reduce the peak load due to seasonal construction. In road construction it was undertaken a year ago, by letting contracts in the fall to induce winter shipment and storage of materials. While this policy was inaugurated primarily as a means of reducing unemployment the argument was also urged that it would reduce transportation delays by encouraging the winter accumulation of materials and so cut down the summer peak. The undertaking was largely a failure because it involved a partial shift to winter operations in a kind of construction which practice has set down as peculiarly a summer task, without having previously paved the way by demonstrating its practicability and securing co-operative action of producers, railways, contractors and state highway departments. For the same reason the efforts of a number of states to induce winter stockpiling of road materials by paying estimates on the material in stock have been only partially successful. There is hardly a better recent illustration than these experiences of the need of opening up by research and analysis the entire possibilities of winter construction as an economic practice.

All the traditions of railway transportation practice hold construction materials and particularly sand, gravel, broken stone and similar low-classification freight, as non-preferential freight. There can be no better evidence of this than the latest ruling of the Interstate Commerce Commission made after repeated protests from producers' and contractors' organizations against previous similar rulings. Obviously any change in this situation requires concerted study by the construction and transportation industries.

Regarded in its most favorable light the way to co-ordinating production, railway facilities and demand is long and has many turns. It can be avoided under favorable conditions by developing local supplies and other means of transportation than railway. Again the best illustrations are furnished by roadbuilding. Example after example of the successful utilization of local aggregates, requiring only short hauls, are furnished by whole states, by counties and by individual operations. In addition, investigations like that in Iowa on the use of high-sand, pit-run gravel and in Kansas on fine river gravels indicate possibilities of extending the range of usable materials so as to make construction in many states virtually independent of railway transportation facilities and rulings.

Briefly the problem of lost time due to service delays resolves itself into:

1. Co-ordinating production, railway facilities and demand.
2. Activating railway managements and railway regulatory bodies to place construction materials among the products having preferential consideration in time of transportation shortage.
3. Developing local supplies of construction materials (a) by widening the range of materials approved for use; (b) by working out the best methods of mining, preparing and delivering materials from local deposits, (c) by determining limits of economic production and delivery.
4. Investigating the mechanics and economics of truck and industrial railway haulage from local pits and quarries.

Labor Delays—Strikes and seasonal employment are responsible for the greatest part of the lost time chargeable to labor. Winter idleness has only to be overcome to correct in a large measure seasonal unemployment, and means of doing this have been considered in a preceding article. Strikes, turnover, incompetency, insubordination and inefficiency generally, as causes of labor delays, constitute a sociological problem primarily —a problem of adjusting human relations that waits on time for a solution. There are factors of the problem, however, which engineers and contractors may determine. One is the volume and rate of construction labor turnover. Another is accident prevention as a means of reducing lost time.

Delays of Direction—There are arbitrarily embraced under this heading a number of allied causes of lost time involved in the personal direction of construction.

In construction the individuality of every considerable operation places an especial responsibility for personal planning on the works managers—engineer and contrator. Unless they work together to schedule work, to keep close records, to determine and agree upon performance, to settle on qualitative standards, time is lost. Time is lost, also, unless the engineer promptly approves finished work and pays for it promptly; unless he renders decisions and supplies information as soon as they are needed. It is lost when any similar neglect is shown by the contractor in carrying out his obligations. To ensure the reduction of these time losses:

1. Finance the operation so that the scheduled progress can be maintained and a surplus of money be available to meet contingencies of extra work or exceptional performance.
2. Unify contract requirements and construction practices so that plant and organization require the least modification in passing from operation to operation.
3. Promulgate the laws, rules and practices of construction management as they are formulated and executed by the leading construction organizations.

Delays of Inefficiency—Efficiency methods reduce lost time in the sense that they utilize time more intensively—or at least they have this purpose. Working night shifts utilizes more of the 24 hours of a fair day but it does not help to retrieve a rainy day from total loss. Nevertheless no consideration of the problem of reducing lost time in construction is complete unless these efficiency methods are made a factor. Unfortunately for contractors and construction "scientific management" in one period was so exploited that it appealed to the strong sense of derision of the men who labor under the rough conditions of the caisson chamber or an ocean breakwater. The term "unfortunately" is used seriously because there are determined principles and laws of construction management and there are developed rules for reducing costs that will help the contractor.

These methods and the decrease of inefficiency are not properly in the scope of this series of articles. The subject is mentioned here, however, to point to its importance and to encourage the development in this direction of a collateral line of inquiry.

* * *

Proposed Organization for Research

IN THE preceding articles lost time in construction has been considered sufficiently to present the problem which has to be solved. It is a difficult and in its economic aspects a complex problem. Enough possible ways are evident, however, to demonstrate that a solution is possible by processes no more difficult than engineers have mastered in solving many of the purely technical problems of their profession. The line of procedure is obviously the same: (1) Determine the facts by research, (2) correlate and analyze the results, (3) formulate procedure.

In the last analysis, however, the question is not whether engineers and contractors can find a solution but whether they will undertake to find it. Unless they adopt the indefensible attitude that solution is not worth while one cannot see how they may in self respect avoid the task. Every phase of the construction industry is now well organized for group action. Engineers, contractors, producers, manufacturers and workers have prosperous and well equipped associations through which they can function collectively. There are co-ordinating bodies. The stage is set for quick action because the public is in a receptive mood toward any intelligent plan for reducing waste.

Suggested Organization—To inaugurate the study of lost time in construction it is suggested as a basis of

discussion, that five national research committees be organized with local contributing committees and a general co-ordinating committee. The five research committees and the subject they are to investigate may be as follows:

1. *Possibilities of Increasing Winter Work.*
   A joint committee of the American Society of Civil Engineers and the Associated General Contractors.
2. *Methods of Reducing Rain and Mud Delays.*
   A joint committee of the American Society of Civil Engineers, the American Association of State Highway Officials and the Associated General Contractors.
3. *Methods of Reducing Equipment and Plant Delays.*
   A joint committee of the Manufacturers Division, American Construction Council, and the Associated General Contractors.
4. *Methods of Reducing Delays in Service.*
   A joint committee of the American Railway Association, the American Society of Civil Engineers, the Associated General Contractors and the American Construction Council.
5. *Methods of Reducing Delays of Direction.*
   A joint committee of the American Society of Civil Engineers and the Associated General Contractors.
6. *Co-ordination of Committee Activities.*
   A joint committee of the American Construction Council, the American Society of Civil Engineers and the Associated General Contractors.

Each committee, as it completes organization and develops its subject, will create the requisite subcommittees of its own body and will outline its requirements in respect to contributing committees of local and subsidiary technical and industrial associations. Its function will be to express its subject nationally while the contributing committees express it as related to one locality or to one industry.

Each committee will function independently except in its relationship with other committees where the co-ordinating committee will exercise an allocating and co-ordinating service. This committee, too, will express the group action of all committees and their group needs as for example, special financing, when these are determined.

Additional committees may be organized as the progress of the investigation discloses their necessity. Their objects and allotments of duties and their co-ordination with existing committees will be determined by the co-ordinating committee in conference with the chairman, or a substitute delegate, from each of the other committees.

In developing the thought behind the exposition of lost time in the preceding articles, two obstacles have manifested themselves in every discussion held with engineers and contractors. They are in doubt whether (1) a working organization is practicable and (2) money can be secured to finance the work. Having an organization which will function aggressively and enough money, it is conceded that a program can be developed which will justify the support of the construction industry. It is submitted that the organization which has been outlined will meet the requirements. Now what about the money to finance the organization?

Plan for Financing—There is no money in sight. None of the engineering societies or industrial organizations has on hand any considerable resources to devote to any activity outside its routine functions. These are the very first assertions that meet any proposal of a plan to investigate lost time. Instead of being discouraging they merely indicate what was to be expected. There is never a fund awaiting any enterprise. It has to be created when the enterprise presents itself. No one knows this condition better than do engineers and contractors. They have to use no different methods in meeting it when a research program is proposed than when a water power development or an irrigation enterprise is involved.

Specifically, the first action to be taken is to "sell" a plan to investigate the possibility of reducing lost time in construction. There is enough money in the industry to pay the price if once it is convinced that the purchase will be profitable. The sole question is:

Obviously a clear description of the commodity offered is the first necessity. Next, ability to deliver has to be shown; third, value has to be demonstrated, and, finally, the price has to be named. Concretely these involve a prospectus, an organization, a program and an estimate of cost. In brief, the procedure is that which engineers and contractors are following in every considerable undertaking which they attempt.

With the previously outlined organization completed, which can be accomplished at very little expense, a program and an estimate of cost are not difficult to arrive at nor will they cost much. Committees whose members are appointed (1) because of their belief in the value of the investigation and (2) because of their reputation for earnestness and industry in performing an assigned task will demonstrate that they need very little money to achieve results. When the program is formulated and its estimated cost is determined, that is, with something tangible to sell and a clear statement of its price, the task of finding customers does not present difficulties which any number of salesmen in the construction industry are not accustomed to meet and overcome all in a day's work.

Inspectors Reduce Truck Overloading

A crew of five deputy inspectors each equipped with an automobile and two loadometers have been working on California highways under the direction of a superintendent in a campaign intended "to protect state and county roads from abuse by overloaded and speeding trucks and from impact by defective and insufficient rubber tires."

These men work under the newly organized traffic-regulation department of the California highway commission. Between March 1 and May 1 they inspected 277 trucks, finding 27 or 9¾ per cent violating the gross weight limit of 30,000 lb.; 111 or 40 per cent overloaded on a basis of tire width and 35 or 12⅝ per cent using solid tires on which the rubber was too thin. Fifty-one convictions were obtained and 104 overloads were adjusted or removed. These percentages are appreciably less than those for the previous inspection periods. Regarding the attitude of truck owners and operators the commission states: "The inspectors have found that the majority of violations have been due to ignorance and when advised of the legal requirements drivers have evidenced a willingness to bring their vehicles and loads within the law."

Test Arrangement for Measuring Skew Arch Thrust

EXPERIMENTAL study of the distribution of thrust at the abutment of skew arches is being undertaken by the Bureau of Public Roads at its Arlington Experiment Station, near Washington. The plan to carry out such an investigation was announced a few weeks ago, but information as to the methods to be used in the study has just become available.

The test object is an arch of 7-ft. span, 4½-ft. width from face to face, 2-ft. rise and 2-in. crown thickness, resting on abutments 2 ft. high. The arch barrel is reinforced with ½-in. bars. The abutments are tied together at the springing line by a number of tierods parallel to the arch faces and two diagonal rods, which are to hold the arch against spreading in the direction of the span or distorting in the direction parallel to the abutments. The arch is to be loaded by a group of adjustable springs shown in the views herewith, and the deformations of the arch are to be measured by strain gage. One abutment will be held against horizontal and vertical motion, while the other will be supported vertically by four steel blocks with spherical face, resting on plane steel surfaces coated with lampblack, by means of which the reactions can be measured. These gages are of a type originated by Professor Kreuger of Stockholm. Pressure of the spherical on the flat surface produces a circular mark on the coated surface, whose diameter (measured by microscope) corresponds to the amount of the pressure. The device gives a measure of force with practically no motion of the measuring device. Similar pressure gages will be used to measure the horizontal thrust of the movable abutment, for which purpose the abutment is surrounded by steel angles secured to the floor, between which and the abutment the gages are to be inserted.

AT LEFT, COMPLETE 7-FT. SKEW SPAN, WITH TIERODS AND LOADING DEVICES
AT RIGHT, ONE OF THE LOADING SPRINGS WITH ADJUSTING SCREW

The multiple-spring loading arrangement serves for applying load in a convenient, easily controllable manner. There are 42 individual springs, each capable of carrying a load of 1,500 lb., which bear on concrete lugs formed on the arch extrados. Over each spring there is a vertical 2-in. pipe bearing against a solid overhead structure, and allowing adjustment of the spring pressure by means of an adjusting screw fixed in the end of the pipe and bearing down on the top of the spring. The springs being previously calibrated in a testing machine, it is possible to adjust the load applied to any one spring very precisely, without the trouble of manipulating weights.

Thomas H. MacDonald, chief of the Bureau of Public Roads, says concerning the test program: "As progress is made with the plan, modification may be necessary. A number of measurements will be taken under different loadings, so that it will be some time before the arch is finally loaded to destruction."

Water Power Possibilities of the Hudson Being Studied by New York Commission

THE New York State Water Power Commission has issued a report entitled "Water Power and Storage Possibilities of the Hudson River" which is the result of an extended study of the hydrology of that river. The report was prepared under the direction of Frank M. Williams, state engineer, at the request of the New York Water Power Commission, under recent laws directing the continuance of investigations heretofore conducted by the Conservation Commission of the water-power resources of the state.

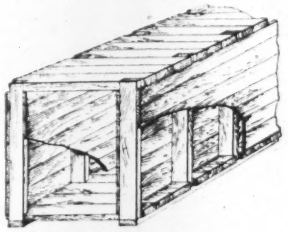
Statistics given show that 362,000 hp. on the Upper Hudson are available of which a little over one-third is developed. Thus excepting only the Niagara and St. Lawrence Rivers, the Hudson River is the most important stream from a water-power viewpoint in the State of New York. The development of a large part of the undeveloped water power depends, to a greater or less extent, on the construction of a system of fourteen storage reservoirs, having a total capacity of 70 billion cubic feet. It is estimated that these reservoirs, the principal ones being the Sacandaga, Gooley, Piseco Lake and Schroon Falls, would cost $24,292,000. Estimates are given which indicate that the value of the storage in these reservoirs will many times exceed the cost, and that the reservoirs would not only increase the available water power on the Hudson, Sacandaga and Schroon Rivers, but also mitigate flood damage, with the consequent insanitary conditions. It it also expected navigation will be improved.

Included in the report, which consists of some seventy-five pages, are fifteen tables giving data relating to drainage areas, rainfall stations, stream-gaging stations, storage reservoir possibilities, and effects of storage on the water powers. It also contains eighteen maps and diagrams together with several photographs.

Creosoted Pine Storm Sewers at Lafayette, La.

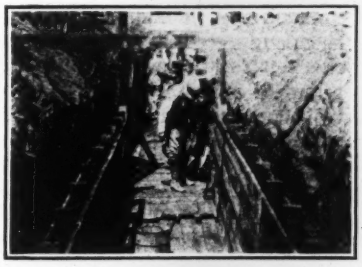
BY L. J. VOORHIES
District Manager, J. B. McCrary, Engineers, Atlanta, Ga., and Lafayette, La.

IN 1919, Lafayette, a growing municipality of Southwest Louisiana, voted a bond issue of $425,000 for various municipal improvements in which was included an item of $75,000 for drainage. The area of the city is approximately 1,500 acres and the topography is very flat. The two main drains which needed improvement consisted of large open ditches along some of the streets. Neither of these ditches could be enlarged and deepened without narrowing the streets materially, to say nothing of the danger to traffic of large open ditches. One of the drains serves the business district and this ditch had to be deepened over 3 ft. to take care of the sub-surface drainage of an area about to be paved. The other drain serves a residential section of about 600 acres which was flooded for hours and sometimes for a whole day following frequent heavy rains. It was, therefore, necessary to construct storm sewers in both cases. To do this with concrete, brick or segmental sewer tile would have cost $160,000 at that time, but only $75,000 was available. Both sewers were built of creosoted yellow pine with the $75,000. It is expected that the pine sewers will last at least 15 or 20 years, at the end of which time the saving in first cost of $85,000 plus interest will be more than sufficient to rebuild the sewers with concrete or other permanent material. In the meantime a crying need for drainage is being taken care of. Moreover, since these trunk sewers were constructed on the established grades developed in the design of a complete storm sewerage system for the entire city, lateral sewers of terra cotta pipe or concrete in sizes up to 33 in. in diameter can be constructed at the proper grades as the more important streets of the city are paved. In fact, there is now nearing completion the paving of several blocks aggregating 20,000 sq.yd. which could not have been properly drained had not the main storm sewers been constructed. Domestic sewage is taken care of by a separate system and sewage-works which make it impracticable to admit even a small quantity of storm water in that system.



TYPICAL DESIGN OF SEWERS

Main storm sewers to replace open ditches in Lafayette, La., ranged from 2½ ft. wide by 3 ft. high to 5⅝ x 6½ ft., inside measurements. The dimensions of the lumber were: sills and posts, 2 x 4 and 2 x 6 in., according to size of sewer; bottom, 2 x 6-in.; walls, both inner and outer, 1 x 6-in.; top, 2 x 6, 3 x 6 and 4 x 6-in.



BUILDING STORM SEWER

Sills, posts, walls, bottom and top of creosoted yellow pine.

The specifications called for long-leaf yellow pine, square edge and sound, treated with 16 lb. of creosote per cubic foot, the oil to be a distillate of coal-gas or coke-oven tar, complying with the following requirements:

1. It shall contain not more than 3 per cent water.
2. It shall contain not more than 0.5 per cent of matter insoluble in benzol.
3. The specific gravity of the oil at 38-15 deg. C. shall not be less than 1.03.
4. The distillate based on water-free oil, shall be within the following limits: Up to 210 deg. C., not more than 5 per cent; up to 235 deg. C., not more than twenty-five per cent.
5. The specific gravity of the fraction between 235 deg. C. and 315 deg. C. shall not be less than 1.03 at 38-15.5 deg. C.
6. The residue above 355 deg. C. if it exceeds 5 per cent shall have a float test of not more than 50 seconds at 70 deg. C.
7. The oil shall yield not more than 2 per cent coke residue.
8. The foregoing tests shall be made in accordance with standard methods of the A.W.P.A.

If a creosote-coal tar solution is used the specifications will be the same as above with the following exceptions:

2. 2 instead of 0.5 per cent.
3. 1.05 to 1.10 instead of 1.03.
5. Residue above 355 deg. C. if it exceeds 25 per cent shall have a float test of not more than 50 seconds at 70 deg. C.

The design and specifications were prepared under the direction of the writer by the J. B. McCrary Co., municipal engineers of Atlanta, Ga., and Lafayette, La., who also supervised the construction for the city. The construction work was done by local contractors. The lumber, aggregating 430,000 ft. b.m., was purchased by the city direct and furnished by the Creosoted Materials Co. of New Orleans.

Corrosion Under Oil Due to Chlorides

Rusting of rifle bore surfaces under the oil with which they were coated for protection has been found chargeable to the presence of potassium chloride, according to an investigation recently reported by W. J. Huff in a technical paper of the Bureau of Mines. A very common difficulty with gun barrels is that after they have been fired the interior of the barrel corrodes, and no method of preventing this corrosion has been developed, although certain grease mixtures appear to have some effect. The corrosion proceeds under the oil film just as though the oil were not there, but it does not continue indefinitely, as the corroding agency seems to exhaust itself after a time. A carefully planned series of experiments revealed the fact that this after-corrosion does not occur at low or normal degrees of humidity of the atmosphere, but only when the humidity is high, well over 50 per cent. Still other experiments showed that the cause of the corrosion could not be removed by wiping out the barrel after firing, but that it could be removed by washing out with water or aqueous solutions. These and other studies finally led to the conclusion that potassium chloride, formed by decomposition of the potassium chlorate in the powder in its explosion, is the cause of the after-corrosion. The author points out that sodium chloride, or ordinary salt, is likely to be similarly troublesome as a cause of erratic corrosion in the case of other steel objects. Bright steel articles coated with oil or grease to protect them during shipment may rust under the oil film as a result of the action of sodium chloride deposited in workmen's fingermarks made in handling the article before it is oiled.

Contract System for Railway Maintenance Work

New Field for Contractors Seems Widening—Management and Cost of Work by Contract and by Railway Force Account—Practice, Experience and Opinions

By E. E. R. Tratman
Associate Editor, *Engineering News-Record*

SHOULD railway maintenance and improvement work be done by contract? What are the advantages and disadvantages of the contract system? How is contract work managed and paid for? How does it compare with railway force work in efficiency and economy? To what extent has it been employed, and what have been the results of experience? These are questions which have become prominent during the past two or three years and which are of direct importance in relation to recent railway labor developments.

The following review of the situation is based upon an extended inquiry as to practice, experience and opinion on a number of railways. Great variations in practice and opinion are to be expected in view of the relatively small proportion of this work which has been done by contract, so that the contract system can hardly be considered as established definitely, while uniform and effective means of handling it remain to be further developed. Furthermore, there is a rather wide objection to adopting the contract system for work which may be affected by or may interfere with traffic on operated lines, although this difficulty has been overcome in several cases.

To supplement the summarized information given herewith, reference may be made to two previous articles dealing with contract work of this kind. One relates to the ballasting of some 2,000 miles of line on the Missouri Pacific Ry. (see *Engineering News*, May 4, 1916, p. 828), and the other relates to general heavy maintenance work on about 400 miles of the Canadian Pacific Ry. (see *Engineering News-Record*, March 9, 1922, p. 399).

Classification of Work—In the first place, the different kinds of railway work need to be divided into certain classes to which the contract system has been applied in varying degree. This classification may be made as follows:

1. Building branch lines, industry spurs, second track and sidings; also track elevation or elimination of grade crossings, and extending or enlarging freight yards and engine terminals. Such work is done already to a large extent by contract and has little relation to maintenance or operation of existing lines, except in double-tracking and the elimination of grade crossings.

2. Track work such as is done usually by extra or floating gangs. This work includes heavy ditching and widening of cuts, renewing ties and rails, ballasting, surfacing, relaying switches or turnouts, building fences and renewing spikes, rail joints, tie-plates and rail anchors on long stretches of line. Several railways have employed the contract system for different items of work in this class to a varying extent for years.

3. Track maintenance of the kind done by the regular section gangs. This work includes general daily inspection and policing, respiking, tightening bolts, clearing ditches, cutting weeds, maintaining track in line and surface, and repair of fences and crossings. Few railways have tried contracting for this general work of maintenance and the actual experience with the system has been so small as to be negligible. A recent attempt to introduce it more widely led to very strong opposition by railway labor, with the result that this step was either abandoned or postponed indefinitely. With such contracts the work probably would be done largely by floating gangs such as are employed for that in class No. 2.

4. Bridge and building work; repairing bridge decks and trestles; building water stations, coaling stations and engine houses; renewing old bridges and replacing old trestles with concrete structures. All such work is done extensively by contract, although some railways do most of it by their own bridge and building departments. Large bridge construction and renewal is rarely done by company forces.

5. Watching road crossings. This has been done to only a limited extent by contract and was included in the controversy noted in relation to class No. 3.

6. Operating coaling and water stations and pumping plants. In this line of work the contract system has been introduced only to a small extent and mainly in the way of making contracts with employees who are engaged in other lines of work but can handle this conveniently in addition to their other duties. It has been suggested that in many cases it would be much cheaper for the railway to contract for maintaining a supply of water in the tanks at a water station than to keep a pump-man on a monthly-pay basis.

Practice and Experience—Of twenty-four large railways sixteen have used the contract system more or less in maintenance work, but only eight have used it to any large extent. Rail and tie renewals and track ballasting are the most usual items of work done by contract. Other work includes track surfacing, placing tie-plates and rail anchors, replacing worn splice bars, ditching, widening cuts, cutting weeds, and building and repairing fences. One road contracted for ballasting at a time when it could not obtain men for work that needed to be done that season. In most cases the contracts have covered specific kinds of work.

The extent to which the contract system has been employed on different roads varies from small jobs to 80 per cent of the ballasting and 75 per cent of the rail renewals in a given season. Prospective economy is given almost universally as the reason for introducing or experimenting with the contract system. Labor conditions are given as the reason in two or three cases. Opinions differ widely, however, as to whether ultimate economy is really obtained, and whether the efficiency of work done by a contractor's force is equal to that of work done by railway forces.

Two roads which have not used the contract system for actual work have used it in securing men, labor contractors being employed to furnish men at times and places when an adequate force could not be obtained directly by the railways. This practice was followed to some extent during the World War. But in these

cases the men worked as employees of the railways, so that these are not instances of work done under the contract system.

Opinions on Contract Work—Returns from the several railways indicate that opinions are divided about equally as to the merits of the contract system in track work of the kind done ordinarily by extra or floating gangs. Of seventeen direct statements, nine are favorable and eight unfavorable, but two engineers giving favorable replies have no experience of their own on which to base the opinion.

The general substance of the favorable replies is to the effect that with contract work there is greater economy combined with greater production and equal efficiency, but one railway engineer of wide experience with such contracts adds the cautionary phrase "provided that the work is rightly handled." Another estimates an average saving of 25 per cent in cost for such work as rail renewals, ditching, widening cuts and replacing trestles with concrete structures. This saving he considers due to the advantage of lower rates of pay and longer working hours for contractors' forces, besides securing greater efficiency as a result of better supervision than is given usually to railway forces.

On contract work also there is less liability of interference by the railway labor unions in regard to rates of pay, hours of work and what work the men may or may not be allowed to do. Further, a contractor can increase and reduce his force more rapidly to meet changing conditions. It is this difference in wages and working hours, together with the greater flexibility in adjusting the force to the work, which is considered one of the main factors resulting in economy by contract work.

Some of the engineers who favor the contract system express the opinion that increased efficiency or output of the laborers will give them increased earnings but will reduce the cost to the railway company. On the other hand, other engineers consider that the actual cost of the work will be greater if done by contract. In fact, some of those who have tried the contract system for reasons of economy are doubtful as to whether there is any ultimate economy. One reply says definitely that comparisons of force account costs with contract bids show a decided economy in favor of the former. Again, one engineer considers that there is no economy if the railway is equipped with modern machinery. As an instance of this, with the introduction of ditching machines a certain railway abandoned the contract system previously employed for team and hand work in ditching and widening cuts.

A difficulty noted by two or three engineers is that of getting a contractor to keep the price down when any cost-plus system is used. But where contractors bid in competition or unit prices, as is the practice on some roads, this difficulty should not be experienced. It has been stated also that the contractor naturally would endeavor to obtain the maximum output from his men and might get more work or higher labor efficiency than the railway company could obtain from its men. But while some engineers consider that this would effect a saving in cost to the railway, others question whether the real efficiency would be as high as if the work was done by railway employees.

There is no doubt that strict and continuous supervision by railway officers is essential to success with contract work, and this is especially the case where this work interferes in any way with the operation of traffic. In fact, one of the strong arguments made against the contract system is that it may put work on an operated line into the hands of outsiders, with consequent difficulty in placing responsibility for train delays or safety of operation. This objection is offset, however, by the fact that in actual practice many cases of this kind have been handled by contract with satisfactory and successful results.

Another slightly different argument is that the contract system is "wrong in principle and detrimental to the service" in putting railway work in the hands of men who have no interest in the railway as their employer, with the resultant loss of loyalty and team work and other advantages due to a force of contented employees. Furthermore, contract laborers are not likely to be skilled in such work as tamping, track lining or switch renewals. An obvious answer to this objection is that under present conditions it is difficult in many cases to organize and to maintain a force of skilled men as railway employees. And for work of the class under consideration a permanent force is not maintained. Taking, for example, the case of an extended stretch of rail renewal and track surfacing which requires a large gang, it seems unlikely that there would be much difference in the quality of a railway force or a contractor's force. Relative economy and efficiency must depend largely on the organization and methods in individual cases.

Cost of Contract Work—Few definite replies are made as to cost of work or systems of payment. Cost-plus-percentage is considered by one engineer as being the most convenient, but he states that this gives the contractor an incentive to keep the cost up, while on the other hand, cost-plus-fixed-fee gives no incentive to keep the cost down. The cost-plus-percentage system has been used on different roads in paying for spacing and renewing ties and for gathering up old material after relaying rails. Cost-plus-fixed-fee is mentioned definitely only in one case, and that was for relaying rails. The fee ranged from a minimum when the total cost was high to a maximum when the cost was low.

Unit prices are sometimes per mile and sometimes per piece. In the former case, the price covers all work of the specified character within a specific territory. This method has been applied for rail renewal, for spacing ties in advance of rail renewal, for ballasting and for surfacing track. The price for surfacing varies with different amounts of lift. In piece-work payment, the unit price may be per tie renewed, per switch or turnout relaid, and per tie-plate or rail-anchor placed.

One road reports that where rail renewal by contract has been paid for at a unit price and at cost-plus-10-per-cent the results were about the same. In both cases they were slightly below the engineer's estimate based on paying railway labor the same price as that paid by contractors. Unit prices are likely to be low when work is let by competition based on the railway's detail specifications, stating explicitly what part of the work the contractor is to do and what part the railway will do. As contractors become more experienced in work of this kind the contracts and prices will tend to become stabilized.

Railway contract work is usually under control of the contractor's foreman or superintendent, subject to supervision by railway inspectors or timekeepers who are on the job continually and by the roadmaster or division engineer, who should make frequent visits. It is considered important that in addition to inspection

by these local officers there should be occasional inspection by a superior officer, such as the chief engineer or chief engineer of maintenance or their representatives.

Payment to contractors is made usually on the division engineer's monthly or semi-monthly estimates of work done, but small jobs may be paid for on completion. In either case a certain percentage is usually retained to protect the railway company against liens that may be filed for labor or material. This percentage is paid within a period specified by the contract. One engineer points out that the monthly estimates of work should be regarded as of a partial or preliminary character, since the engineer is more ready to give an estimate satisfactory to the contractor when he knows that it is not to be taken as final or conclusive in regard to the amount or extent of work done.

In regard to cost and management of the work, another engineer submits the following statement:

> On contract work the cost begins and ends with the execution of the job. But with railway force work the cost continues, since other jobs must be found for the extra gang and these may not be the most essential or necessary, compared with the amount of money available. But on the other hand, railways are not so organized as to have skilled specialists and competent inspectors always available who can prepare plans and specifications to cover a repair job with the necessary precision. For this reason, extra bills, cost-plus and other methods are resorted to, which are more or less prejudicial to the efficiency and final cost of the work. There is much added bookkeeping and the work is frequently productive of disputes and disagreements that occupy the time and attention of officers who have other duties.
>
> About 40 per cent of the cost of the job is for material which for various reasons may be delayed or not available in the order and manner required for economical use. As the contractor is concerned financially he must take quick action and get supplies by the most direct means, which is not always possible for a railway. The foreman or other superintendent of work for the railway is not financially interested, and delays which occur through no fault of his have no such significance to him. But the contractor in getting material has a tendency to specialize because it is the essence of his work. This may result in odd or unusual sizes, which later may increase cost of renewal on replacements, whereas if the railway does the work it will get the standard stock even if it is delayed in doing so.
>
> Proper character of the men in charge and proper relations between them are essential features of a successful contract system. With individuality, familiarity and competency on the part of the contractor and the railway representative the work will be successful and the road doing the work by contract will be satisfied. Where these requirements are lacking in either party the railway will not be satisfied and an unfavorable report on the contract system is likely to result.

Tools and Equipment—Little information is given as to details of work, but such details for two important roads will be found in the earlier articles noted above. The railways usually furnish camp cars and work train service for distributing material. Until the present year many of them furnished also the hand tools, but some have now altered their practice and leave the tool supply to the contractor, supplying only such larger tools as a contractor would not be likely to possess. This change is due partly to the fact that the tool equipment will vary with the amount and extent of the work to be done. A stronger reason is that difference of opinion arises as to depreciation from use, since there is no simple and practical means of determining the depreciation value in proportion to the total expense involved in purchasing tools.

Since the essence of the contract should be to get the work done with the least expenditure it is evident that the proper plan is for the two parties to the contract to pool their interests and supply such equipment as they can to avoid increasing the cost. Ditchers, spreader cars, locomotive cranes, motor cars and push cars are furnished sometimes by the railway and sometimes by the contractor. This depends no doubt upon the contractor in individual cases, since only a contractor specializing in railway work would have such equipment. Distribution of material and collection of old material after the work (as in rail and tie renewals) is done sometimes by the railway and sometimes by the contractor.

Bridge and Building Work—In this special kind of repair and maintenance work, there may be economy in having small repairs done by local men under contract instead of by a traveling gang of the railway's bridge-and-building department. One officer of wide experience in this department suggests that if the contract work is based on proper specifications it eliminates the interference of "a long list of uninformed officials" who have authority over the bridge and building forces. This lack of concentrated authority and its result in disturbing a regular program of work is a rather frequent source of complaint in this department. Another complaint is that crude and antiquated methods in the handling of materials and supplies through the railway storehouse are detrimental to efficient work by company forces.

The contract system is considered advantageous on large work requiring special equipment and a larger experienced organization than the railway can afford to maintain. Further, the contractor has greater freedom in hiring and discharging men, so that he can increase or decrease his forces to suit variations, in the work. On the other hand, more than one reply indicates that work which does not require unusual equipment or housing can be handled best by a company force. In a case where a large amount of bridge painting needed to be done when there was a shortage of labor, the work was let by contract. The railway furnished the paint but no equipment. Other roads have furnished work train service and camp cars for contractors on similar work.

Conclusions—It will be evident from what has been said for and against the contract system in railway improvement and maintenance work that opinion is divided as to the merits of this system. Further, experience has been too limited to develop definite methods of handling and controlling such contract work. But it is evident also that highly satisfactory results as to efficiency, economy and general advantage have been obtained in several individual cases. These cases are sufficient proof of the practicability of applying the contract system to this class of work. It remains, therefore, to work out the details which will perfect the system and lead to its more general adoption. Much depends upon the way in which the specifications and contract are drafted and the way in which the work is handled and supervised. Essentials to success are integrity, a fair-minded spirit on both sides and active co-operation between the contractor and the engineer.

Surface-Treated Gravel for Light Traffic Streets

Tarvia B Applied Cold—Good Maintenance Essential —Annual Cost for Four Years Less Than Seventeen Cents a Yard

By D. B. Davis
City Engineer, Richmond, Ind.

As THERE is an abundance of good gravel in the City of Richmond, Ind., that material was used in constructing its streets some 25 to 35 years ago. The gravel was laid to a depth of 12 in. In the course of time these gravel surfaces required resurfacing, and it was decided to do this with the local gravel which passed a 1½-in. ring and contained 13.3 per cent of clay coating the pebbles and not in the form of lumps.

This new gravel surfacing was spread to a depth of from 4 to 5 in. and was rolled and water-bound, as in macadam construction. Special care was given to finishing the surface. In 1919, it was determined to experiment with surface treatments of Tarvia B on two of these gravel pavements. The success attained on these streets resulted in treating others each year.

For successful results the gravel surface must be firm and comparatively smooth prior to surface treatment. Better results are obtained if the gravel street is subjected to traffic for a season.

The preparation of the surface consists in repairing all depressions by filling the same with ¾-in. stone, tamped to about ⅜ in. below the street surface and sealing with hot Tarvia. If there is dust on the surface it can be removed to the gutter with a rotary sweeper.

The Tarvia B was applied cold by means of a pressure distributor. For initial treatment, ⅓ to ½ gal. per square yard was used, with subsequent treatments of ⅓ to ¼ gal. per square yard. Better results are obtained by not applying any covering material in the initial treatments. This allows the bituminous material to be absorbed by the surfacing gravel, which it is to the extent that, after traffic has ironed out the road, investigation shows that a crust has been formed from ⅜ in. to ½ in. thick. Subsequent treatments are covered with a light sprinkling of pea gravel, to the amount of about 5 lb. per square yard.

The city street department does the gravel resurfacing and applies the surface treatments with its own forces. The cost of resurfacing with gravel at present prices is approximately as follows:

	Per Cubic Yard
Bank-run gravel at pit	$0.50
Hauling (6 loads per day, 1⅓ yd. per load; team at 65c. per hour)	0.72
Spreading at 40c. per hour	0.13
Extra man at pit loading at 40c. per hour	0.13
Cost of gravel on street (per square yard of paving)	$0.33
	Per Square Yard
Gravel delivered and spread at $1.48 (5-in. finished depth requires 0.22 cu.yd.)	$0.33
Scarifying and rolling	0.07
Total	$0.40

The cost of the initial treatment of ½ gal. per square yard is as follows:

Gravel covering at $1.50 per cu.yd.	$0.005
Binder f.o.b. track at 13c. per gal.	0.065
Cleaning and application	0.020
Cost per sq.yd.	$0.090

The cost of subsequent treatments of ¼ gal. per square yard is $0.058 per square yard of surface.

It has been found that after traffic has used the treated gravel street for some months, a few depressions may develop, due either to an excess of dust, or a damp clayey spot on the surface prior to the application of the binder. These places will require looking after. This maintenance work is taken care of by a maintenance repair gang, consisting of a team hauling a special wagon containing stone and sand, with the necessary tools, and back of which is hauled a tar heating kettle. This wagon was specially constructed for the work, the running gear being from a discarded horse-drawn hook and ladder fire wagon. The wheels are roller bearing, which permits one team to haul the heavy load. The sand compartment in the rear holds 30 cu.ft. and the stone compartment holds 25 cu.ft. Under the driver's seat is a tank for Tarvia B, to be used for very thin patching. The amount of material carried on the wagon will supply stone and sand enough for pouring two barrels of Tarvia X, which is heated in the kettle at the rear. The kettle has a warming rack which holds an extra barrel, over which is a tight hood. The materials thus carried will supply material for the gang for one-half day.

An average cost for this type of pavement, covering a period of four years, is as follows:

Cost of gravel resurface	$0.400
Initial treatment of ½ gal.	0.090
Maintenance first year	0.008
Second treatment of ¼ gal.	0.058
Maintenance second year	0.003
Maintenance third year	0.003
Maintenance fourth year	0.003
Interest on investment at 5 per cent	0.100
Total amount spent in four years, per sq. yd.	$0.665

This does not include any profit, overhead or tool wear.

Four years of experience with surface-treated gravel has established the following points:

1. Do not treat a gravel surface which is damp or dusty, as it will not incorporate and will soon break out.
2. Apply the treatment uniformly the full width of the street, otherwise it will ravel at the edges.
3. Have the surface firm and smooth before applying the binder.
4. Apply the binder on no street which has not an adequate foundation.
5. Do not apply the binder on any street unless the treatments will be kept up when they are needed. (It has been found here, that ½ gal. per square yard the first year with ¼ gal. per square yard the second year, will keep the surface in such shape that no treatments will be necessary for two years. To put one treatment on a gravel street and then leave it alone will make it worse than if no treatments had been applied.)
6. Give the pavements intelligent maintenance.

Panama Canal Shipping in September

During September, 1922, a total of 240 ocean-going commercial vessels passed through the Panama Canal. Tolls on these amounted to $1,020,064.55 as compared with $1,055,336.76 on 257 vessels during August and $892,001.54 for 221 vessels during September, 1921. In addition to these, eleven small launches and seventeen government vessels passed through the canal. The amount of the cargo tonnage passed through was greater by approximately 50 per cent than that which made up the traffic of September, 1921, and for the first time in the history of the canal the cargo tonnage has exceeded 1,000,000 tons for three consecutive months. Tolls, also for the first time have exceeded the million-dollar mark for three consecutive months.

Experiments With a New Departure in Impulse Wheel Design

EXPERIMENTS made recently at the Philadelphia plant of the William Cramp & Sons Ship & Engine Building Co., by the I. P. Morris department and their associate, the Pelton Water Wheel Co., are said to have demonstrated the success of waterwheels built according to a design radically different from anything heretofore on the market. Small wheels of the new type built for test purposes have shown higher efficiencies than can be expected from impulse wheels of ordinary design and are said to be efficient over a wide range of heads, including those in the neighborhood of 800 to 1,000 ft. where the relative merits of reaction and impulse types are frequently in dispute.

The new design follows the principle of the impulse wheel, but instead of a jet or jets tangentially disposed to the periphery of the runner, the flow in the new design is normal to the runner plane. Further, instead of one or more separate jets to which the buckets are subjected during only part of a revolution, the new design applies the spouting water to all the buckets simultaneously and continuously around the entire periphery of the wheel, that is, the water reaches the runner in the form of an annular ring whose diameter is equal to the diameter of the runner. The flow in this annular ring contains both tangential and axial components.

Regulation is effected by an annular plunger moving axially to close the orifice of the nozzle. A section through the annular nozzle as taken in a plane containing the turbine axis shows a contracting water passage somewhat similar in form to a section through the ordinary needle nozzle. A point of difference, of course, is represented by the tangential velocity components about the axis of the jet which are not present in the jet from the ordinary needle nozzle. Air is freely admitted to both the inner and outer surfaces of the jet and the water does not completely fill the runner buckets, but is in contact with only one surface of each bucket, that is, the action is that of a true impulse turbine.

The advantage of the impulse turbine is therefore claimed for the new design in that changes of pressure through the runner are avoided and there are no forced changes of the relative velocity of the water with respect to the buckets as are required in a reaction turbine where the stream must completely fill the area of the conduit at all points. Therefore, the risk of cavitation due to sudden variations in pressure within the bucket is eliminated, and there is no leakage loss due to poorly fitting or worn seal rings.

Runners for wheels of this design can be built of extremely small diameters, it is claimed, as compared to impulse wheels of ordinary design and units of this type are to be put on the market in commercial sizes as soon as the present experiments are completed and details of construction in larger sizes have been worked out.

German Guns as Road Foundation

According to correspondence from London the Rayleigh (Essex) Parish Council has decided that a collection of German rifles and machine-guns are to be used as part of the foundation of the new London to Southend road.

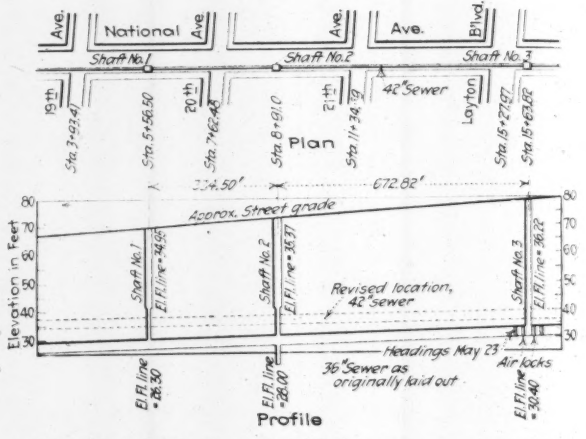
Ferrous Strata Develop CO_2 in Tunnel Shaft

Lowering Water Level Releases Carbon Dioxide—Air Pressure Forces Gas Into Shaft—Men Entering Shaft Killed

BY T. CHALKLEY HATTON
Chief Engineer, Sewerage Commission, Milwaukee, Wis.

CARBON dioxide released by a ferrous earth and forced by air pressure into a pumping shaft of a sewer tunnel killed five men at Milwaukee, Wis., on May 24, 1922. The cause of the accident is so unusual and so likely to exist on other work, that the writer feels a full description may prevent the loss of life at other places.

The Sewerage Commission was having built by George E. Zimmermann, a contractor, an intercepting sewer in National Ave. between 18th and 20th Avenues. The



TUNNEL WORKING, INVADED BY CARBON DIOXIDE

sewer was to be built of plain, monolith concrete, 36 in. inside diameter and at an approximate depth of 35 ft. below the surface of National Ave., which was surfaced with impervious pavement.

Prior to awarding contracts, test borings had been made which disclosed a fairly dense clay strata to a depth of 18 to 20 ft., grading off into fine gray clay and sand, then to fine sand, then into coarse water-bearing sand and fine gravel. A shaft about 14 ft. square was sunk in National Ave. near 18th Ave., which is designated Shaft 1 on the accompanying plan. After sinking this shaft to a depth of 35 ft. it was abandoned on Feb. 27, 1922, because of the infiltration of huge quantities of water. On Feb. 27 another shaft, similar in size and called Shaft 2 on the plan, was begun near 19th Ave. about 334 ft. west of Shaft 1, with the hope of finding less water, which would permit headings to be begun for the tunnel. After reaching a depth of 32 ft. the quantity of water encountered was quite as great as in Shaft 1. For the purpose of reducing the ground water level, this shaft was sunk with a steel caisson, 9 ft. in diameter, from 32 to 52 ft., the upper 32 ft. being timber sheathing.

Shaft 2 was completed about April 7, and sufficient pumps were installed to pump about 1,000,000 gal. per 24 hours. After several days' pumping at this rate, the water horizon was lowered about 12 ft. and thereafter, until the time of the accident, Shaft 2 was used

solely for collecting and removing the water from the adjacent territory and the top was covered by 2-in. planks loosely placed, Shaft 1 having been covered by planks by spikes to the braces.

Upon the completion of Shaft 2, Shaft 3 was driven to a depth of 49 ft., and 672 ft. west of Shaft 2. Cages, hoists, compressors and other equipment for tunneling were set up. Headings were started east and west from the shaft and air locks in each installed when the headings had penetrated about 30 ft. On May 23 air was put on the headings, but owing to excessive leakage about 3½ lb. pressure only could be maintained in the heading, which was not enough to enable excavation to proceed properly.

Careful and thorough examinations were made to determine the direction of air escape, and Shaft 2 was entered several times during the day (May 23) to investigate the leakage, but without success. The compressor was allowed to run all night of the 23rd but no tunneling was done. About 6.45 of the morning of the 24th, the hoisting engineer at Shaft 3 went down Shaft 2, as was his daily custom, to oil the pump. When he reached the first platform, at 35 ft. in depth, he expired in a sitting posture. A laborer went to look for him, saw him apparently asleep, went down the shaft to arouse him and was likewise overcome. The fire department was then called and upon arrival, the men—believing it to be a case of electrocution—put on rubber boots and gloves and went down the shaft to the first platform. All succumbed before they could be rescued. The rescue squad of the fire department then arrived, donned oxygen masks, went down and brought the bodies of the five men up the ladder.

Investigations was immediately begun by the Sewerage Commission as to the cause of the accident. Samples of the air in the bottom of the shaft were taken an intervals of about an hour, during May 24. At the beginning, these samples showed the following:

	Per Cent by Volume
Oxygen	5.93
Hydrogen	None
Methane, CH_4	None
Carbon dioxide, CO_2	8.9
Carbon monoxide, CO	None
Illuminants	None

Samples were also taken in Shaft 1 and showed substantially the same analysis. This analysis disclosed at once the cause of the accident but not the source of the great volume of CO_2.

By the beginning of May 25, the air in Shaft 1 and 2 was normal. Air pressure was then turned on in Shaft 3 at the same pressure as it was on the night of the 24th, and by noon, the CO_2 had increased to 3.3 per cent. The air in Shaft 2 was pumped out until the CO_2 had been reduced to normal and the air in Shaft 3 again put on, with the same result.

This was conclusive evidence that the CO_2 was present in the substrata between the shafts, was in a quiescent state until moved by the air pressure, and, when moved, sought the two open shafts.

Further investigation developed that the water being pumped from these underground strata showed the presence of considerable iron in the ferric state. This water had entirely saturated these strata before operations were begun. As the water horizon was lowered, the space formerly occupied by the water was occupied by air into which the CO_2 in the iron escaped, leaving the iron in the water as it came from the shaft in a ferrous state. This CO_2 would remain in these underground spaces without movement until an agent, such as compressed air, disturbed it.

Without previous experience, it can well be seen how such an accident could occur. The open shafts were simply big holes in the ground, having no connection with the tunnel being driven. Men entered one of them three times a day to look after the pumps, and several men had been down the evening before the accident. No indication of the presence of any gas had been given and no gas was anticipated. The contractor, his men, and the engineers in charge of the work for the Sewerage Commission had, for several years past, been driving tunnels, both in free and compressed air, through all sorts of ground. In many cases the compressed air had escaped in enormous quantities, but no evidence has been obtained of the presence of CO_2 in any considerable quantities although methane was sometimes detected and guarded against. From the light of this experience, my directions have been:

In all open shafts where tunnels are being driven under compressed air—and whether or not such shafts are connected with the tunnel—and in all tunnel headings, whether driven in free or compressed air, keep a miner's, or other open light, constantly burning. Where the water being pumped from the shafts or tunnel workings shows the presence of iron, as disclosed by the brownish stain on things it touches after reaching the open air, particular care must be observed and frequent analysis of the tunnel air must be taken, especially if the work is being done under free air.

I have gone into the description of this accident in greater detail than some readers might think necessary. My object has been to give the picture so vividly to the construction engineer that he can see where it fits into conditions which he may frequently encounter, and while he may so far have been saved from disaster because one of the controlling agencies was absent, all these conditions may be present when he least expects.

Before closing this description, there is one other danger from the presence of CO_2 in underground strata, where compressed air is used in driving tunnels through city streets, to which it might be well to call the engineer's attention. Had no open shafts existed, in the case above described, into which the CO_2 could readily escape, it might have been blown out through any of the surrounding cellars and cause fatalities to those living in the houses. We have had several instances in our work here in Milwaukee, where the compressed air escaped through the surrounding cellar floors at such volume and pressure as to crack the concrete.

Hydro-Electric Project in the Punjab

Plans are being considered by the Punjab Electricity Board for utilizing the water power of the Sutlej Valley Dam and other irrigation water supplies to develop hydro-electric energy. Applications to the board from British and Canadian power interests for concessions to develop the hydro-electric power involved with a lien on the water powers of the Ravi River have been denied, and a resolution published by the board declaring itself unanimously in favor of a government monopoly of water power for the Punjab. It is proposed to distribute the power to concessionaire companies and by price regulation insure low-cost electric current to consumers. In this manner the board hopes to promote industrial development and at the same time safeguard the public interest in the waters of the Punjab Rivers —*Commerce Reports.*

FROM JOB AND OFFICE

Hints That Cut Costs and Time For the Contractor and the Engineer

Charts Covering Design of Abutment Walls of Horizontal Beam Type

By W. B. WALRAVEN
Assistant Engineer, Illinois Division of Highways

THE ACCOMPANYING charts have been prepared by the writer for the design of abutment walls of the horizontal beam type and may prove useful to others who have similar designs to make. Such a wall will be considered as being composed of beams each 1 ft. wide extending horizontally between vertical counterforts. The problem of design is, therefore, to select a suitable thickness of wall and amount of reinforcing to carry the moment and shear developed.

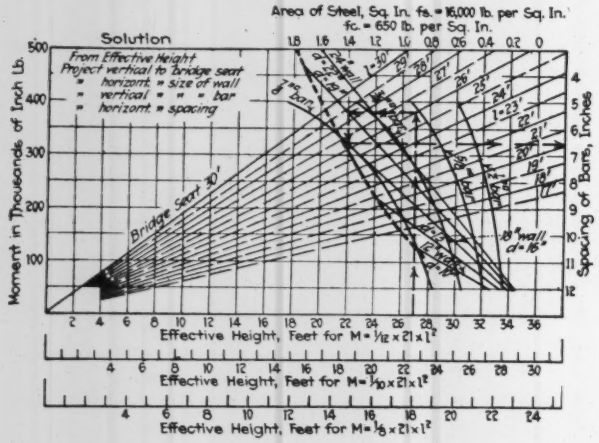

Area of Steel, Sq. In. fs. = 16,000 lb. per Sq. In.
fc. = 650 lb. per Sq. In.
Solution
From Effective Height
Project vertical to Bridge seat
" horizont. = size of wall
" vertical = " " bar
" horizont. = spacing
Moment in Thousands of Inch Lb.
Spacing of Bars, Inches
Bridge seat 10'
18" wall d = 15"
Effective Height, Feet for M = 1/12 x 21 x l²
Effective Height, Feet for M = 1/10 x 21 x l²
Effective Height, Feet for M = 1/8 x 21 x l²

FIG. 1—GRAPHICAL SOLUTION FOR VERTICAL WALLS

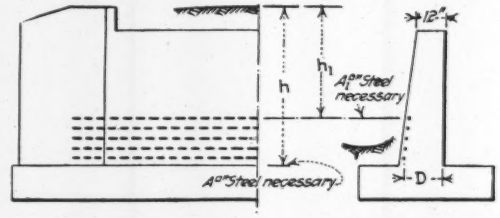
Two assumptions are made: Earth fill imparts equivalent fluid reaction of 21 lb. per square foot for each foot of height; and certain coefficients must be used in moment calculations. For convenience, scales are shown wherein the fixity is such that moment coefficients of 1/8, 1/10 and 1/12 are used.

Fig. 1 gives a graphical solution for the effective depth and the amount and spacing of reinforcing steel necessary to carry the stresses delivered to the wall by the earth filling behind it. Two assumptions must be made in the solution herein given: First, that the earth fill imparts an equivalent fluid reaction of 21 lb. per square foot for each foot of height; and, second, that certain coefficients must be used in the moment calculation. Considering the first of these assumptions, if instead of 21 lb. it is considered wise to use an equivalent fluid pressure of 25 lb., it will be necessary to enter the diagram with an effective height equal to 25/21 times the actual height. By effective height is meant the vertical distance from the crown of the roadway back of the wall to the element of the wall under consideration.

As to the second assumption, since various degrees of fixity may be encountered where the main and wing walls join, it is convenient to show scales wherein the fixity is such that moment coefficients of 1/8, 1/10 and 1/12 are used.

As an example assume an effective height equal to 18 ft. and a fluid pressure of 21 lb., and a support at the wings such as to warrant the use of a moment coefficient of 1/8. With a bridge seat having a clear span of 26 ft., it is found by tracing the path of the arrow (Fig. 1) that a wall with a 19-in. effective depth requires 1.4 sq.in. of steel to carry the stress. This amount of steel will be provided by 7/8-in. square bars spaced on 6½-in. centers. If we assume that the wall is to be of the same thickness throughout, the amount and spacing of steel for any other height may be found by working the diagram in the reverse order.

With a battered wall the solution of the problem is complicated because of the decreasing depth to steel with decreasing height. Fig. 2 furnishes a ready means for solving this problem after the amount of steel necessary to the top of the footings has been ascertained. As an example (Fig. 3) assume the effective height (h) to be 19.2 ft.; the length of the bridge seat (l) 25 ft.; and the effective depth (d) 13 in. From h project the line vertically to the l curve, thence horizontally to



$Z \times h = h_1$ — Uniform spacing assumed

Size of Bars req'd at h	Size of Bars req'd at h_1	$\frac{A}{A_1} = C$	Z for d D=10	Z for d D=13	Z for d D=16	Z for d D=19	Z for d D=22	Z for d D=25	Z for d D=28	Z for d D=31
7/8"	3/4"	1.36	0.736	0.681	0.634	0.594	0.558	0.526	0.498	0.472
7/8"	5/8"	1.96	0.510	0.445	0.394	0.354	0.322	0.294	0.271	0.251
7/8"	1/2"	3.06	0.327	0.272	0.233	0.203	0.181	0.163	0.148	0.135
3/4"	5/8"	1.44	0.694	0.636	0.587	0.545	0.508	0.476	0.448	0.423
3/4"	1/2"	2.25	0.444	0.381	0.333	0.296	0.267	0.242	0.222	0.205
5/8"	1/2"	1.56	0.640	0.578	0.526	0.484	0.448	0.416	0.389	0.365

$$\frac{10 \times h}{[10 + D(\frac{A}{A_1} - 1)]} = h_1 = Z \times h$$

Illustration

Having solved for D and the size and spacing at depth h, the smaller sized bars may be used at depth $h_1 = Zh$
Assume D = 22" and 7/8" sq bars required at h
1/2" sq bars good at 0.558 x h
5/8" sq " " " 0.322 x h
1/2" sq " " " 0.181 x h

FIG. 2—SOLUTION FOR WALL WITH BATTERED FACE

the d curve, thence to the B curve and thence horizontally to Σo. This shows that the total shear amounts to 5,050 lb., the end shear to 36.5 lb. per square inch, and that the bars must have a Σo equal to 5.50 to develop bond, assuming an allowable bond stress of 80 lb. per square inch. This accounts for the one-foot strip immediately above the footing. Remaining strips may be designed by repetitive uses of the charts.

Figure 3 gives values for unit shear and bond under conditions similar to those met with in Fig

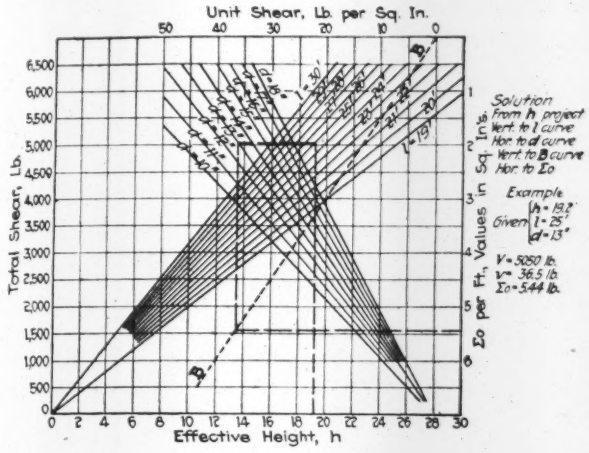

Unit Shear, Lb. per Sq. In.
Total Shear, Lb.
Effective Height, h
Solution from h, project Vert. to I curve Hor. to at curve Vert. to B curve Hor. to Σo
Example
Given: h = 13.2' I = 25° d = 13"
V = 5050 lb.
v = 36.5 lb
Σo = 544 lb.
Σo per Ft. Values in Sq. In's

FIG. 3—VALUES FOR UNIT SHEAR AND BOND

1. However, only a few values of the depth to the steel are given so that confusion may be avoided.

The writer can personally point to hundreds of abutments built by a single highway department using the principle herein outlined.

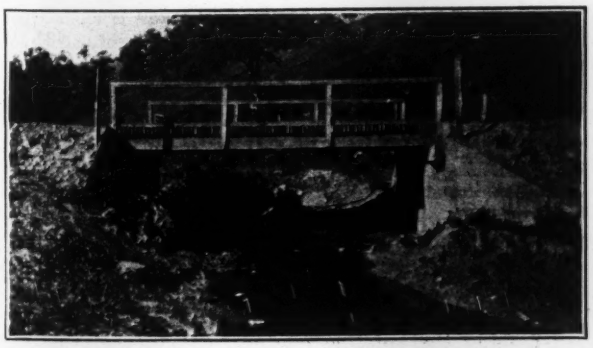
Native Timber Bridges Aid County Highway Program

By R. S. Blinn
Engineer in Charge, Allegheny County Road Work, Sparta, N. C.

BRIDGES built of native white oak for about $9 a lineal foot and of the design illustrated were a material aid in putting through the 40-mile county road program for which $135,000 was raised by the citizens of Allegheny County, North Carolina. On this road work the grading averages about 6,000 cu.yd. a mile and bridges and culverts about 10,000 ft. b.m. This grading and bridge work is costing about $3,500 a mile

The illustration shows a 20-ft. bridge, which cost $180. Several dozen others have been built at about the same ratio of cost. These structures are located about 30 miles from a railway. All material, except nails and drift bolts, is white oak even to the submerged logs which tie together the mudsills upon which the bents rest.

On account of the excessive haul for cement and sand, this type of structure is the cheapest by far, even in the long run, because the interest saved on the difference in cost between a white oak and a concrete bridge will rebuild the wooden bridge every three years and it is fair to say that the white oak will be in good condition for ten years, and, with slight repairs, may last twenty years.



COUNTY HIGHWAY BRIDGE OF NATIVE TIMBER

This is one of several dozen built in Allegheny County, North Carolina, almost entirely of native timber. These structures averaged $9 a lineal foot. This one cost $180.

Form for Computing Areas Mechanically

By J. R. Jahn
Williams & Jahn, Consulting Engineers, Berkeley, Calif.

THE writer believes that the accompanying form simplifies and systematizes the work of balancing traverses and computing areas sufficiently to warrant its use by surveyors having mechanical calculating machines.

The special features are: (1) the condensing of the usual computation form to one of few columns by the consolidation of East and West departures into one column, North and South latitude differences into another, and the elimination of all partial-area columns —algebraic signs are used wherever necessary to differentiate the terms—; (2) column "E or W" is placed

Date 8-28-22
Job No. 267
Lot No. 26
Area 57.6 Ac.
Computed by

Course	Bearing	Dist.	Sine / Cosine	East or West	D.M.D.	North or South	Co-ordinates No.	Co-ordinates East	Co-ordinates West	Remarks
1-2	N 38°15' E	1740.0	.6177 / .7864	1077.5	1077.5	1366.3	1	1000.0	1000.0	
2-3	N 41°28' W	1100.5	.6617 / .7497	695.0	1466.0	746.5	2	1695.5	1338.3	
3-4	S 57°16' W	1572.6	.8419 / .5397	1664.3	-244.3	-1049.6	3	1170.4	1107.1	
4-5	S 49°42' E	1674.3	.7651 / .6440	1282.8	-1381.8	-1083.2	4	956.1	1002.3	
5-6							5	973.9	891.0	82 error
6-7							6			
7-8							7			
8-9							8			
9-10							9			
10-11							10			
11-12							11			
							12			

Note: Balanced dimensions shown above the field observations

FORM FOR TRAVERSE AND AREA COMPUTATIONS

ahead of the column "N or S," and is separated by the column "D M D," which is developed from the column, "E or W;" and (3), the various products of multiplication of terms of the "D M D" column with corresponding terms of column "N or S," are accumulated as an algebraic sum in the machine and the area of the "lot" obtained by dividing this sum by a constant. Where feet are used as units, the constant is 87,120 or twice 43,560.

In practice, the traverse is written into the form in the order in which the courses appear in the field when followed around in a counter-clockwise direction. The sine-cosine column is not filled in, being placed here for those who might desire to use it. The distance term of the first course is set on the keyboard of the calculator and the multipliers (the natural sine and cosine) applied directly to the crank of the machine to obtain the quantities for columns "E or W," and "N or S." The same process is used to fill in all of the terms of these columns. The West courses are now distinguished from the East, and the South from the North, by the minus sign (—) and the algebraic sum of each column is taken. Provided the traverse closes within the allowable limit of accuracy, it is balanced by applying an amount equal to the respective remainders but opposite in sign, to the significant terms of the respective columns, either proportionately or according to accuracy weights. The column "D M D" is now built up in the machine by turning in the first "E or W" term, once for the "D M D" of the first course and again for its

portion of the second one before removing the hand from the crank. This process is continued down the page, the quantity noted after the first turn of the crank being set down in the column "D M D." If the work is properly performed the last two turns of the crank will clear the result dials to 0000.

Now accumulate the products of multiplying each "D M D" by its "N or S" term noting that the product of two plus or two minus terms is positive (i.e., forward turns of the crank) and of two of opposite sign, negative (i.e. backward turns). Divide this algebraic sum by the constant 87,120 for acres from foot measurements or by 100 for acres from chain units.

For mapping, co-ordinates may be computed by starting with the co-ordinates of a known point, such as a corner of pre-computed traverse, and adding algebraically the terms of the respective longitude or latitude differers as illustrated in the form. Here East again precedes North and corresponds to the X of the XY co-ordinate system.

A convenient check on the calculated area within the traverse is possible, by the method of cross multiplication of co-ordinates as follows: accumulate the products algebraically in the machine of the series $(1E \times 2N) + (2E \times 3N) + \ldots - (2E \times 1N) - (3E \times 2N) - \ldots = 2A$ (area), in square feet, which can be reduced to acres by dividing by 87,120.

Intersections can be easily worked out, using co-ordinates, if the two lines are expressed by their equations $y = mx + C$, where x and y are variables, m, the cotangents of the bearings and C, the values obtained by substituting known values in the equation $C = y' - mx'$. The two equations of the intersecting lines may be solved for x by subtracting one equation from the other. This process works out very nicely on the calculating machine. Y is then found in either of the equations and the length of the two lines found from the respective co-ordinates.

Comparison of Finished-Floor Materials

ONE of the members of the Building Managers and Owners Association of New York has made a study of the various materials for use in floor finishing. Materials are rated as to appearance, durability, slipperiness, cost and other considerations. Though of higher ultimate cost travertine appears to lead, in the estimation of the man who compiled the figures. The comparison, taken from a recent bulletin of the association, is reprinted herewith.

COMPARISON OF MATERIALS FOR FINISHED FLOORS

	Ratings					
	Appearance	Durability	Non-slip	Approximate Cost per Sq. Ft.	Average Life, Years	Ultimate Cost per Year
Marble—blocks	A	A	C	$2 25	25	$0.09
Travertine stone	A	A	A	2 00	25	.08
Mosaic—marble	B	A	B	1 25	25	.05
Tile—hard	B	A	B	1 00	25	.04
Rubber tile*	C	B	A	1 40	20	.07
Cork tile—natural*	B	C	A	.60	15	.04
Cork composition tile*	C	C	A	.60	15	.04
Linoleum—battleship*	D	C	A	.45	15	.03
Terrazzo—brass strips	C	B	C	.60	20	.03
Cement—dustproofed	D	B	B	.20	20	.01
Composition—magnesite	D	C	B	.45	15	.03
Oak—quartered sawed†	C	B	B	.50	20	.02½
Maple or yellow pine†	D	B	B	.40	20	.02
Treatment of wood floors	..	..	..	.02	2	.01

*Including cement underfloor.
†Including wood underflooring and sleepers.

FROM JOB AND OFFICE

Hints That Cut Costs and Time

Tractors Prove Advantage Over Teams in River Bank Protection Work

REDUCED cost and greater working capacity or output due to haulage by tractors as compared with teams was found in hauling trees for current retards along the Missouri River near Dakota City, Neb., during the summer of 1922. These retards, which are to protect the river bank from erosion, are composed of groups of large trees having the trunks lashed to cables anchored to concrete piles sunk below the river bed, as described in *Engineering News-Record* of Dec. 15, 1921, p. 966.

As the trees were cut a 5-ton tractor hauled them through heavy underbrush to an open space or a convenient roadway. There the trees were bunched, loaded

TRACTOR HAULING TREES FOR BANK PROTECTION

On a two-mile haul this 10-ton tractor made nine trips over a 10-hr. shift. This was slightly more than five four-horse teams could accomplish.

onto a special two-wheel cart and hauled by a 10-ton tractor through brush, sand and muddy bottom land to the river, a distance of two to three miles. The tractor and cart are shown in the accompanying view. With tractors averaging about 20 working hours per day the trees were delivered with sufficient rapidity to supply two gangs which hauled them into the river to build the retards. Each gang consisted of seven men with a steam hoisting engine or winch. The trees were of various sizes but averaged more than 12-in. butts and were hauled complete, no trimming of leaves or boughs being permitted. With a 2-mile haul the 10-ton tractor made nine trips in a 10-hr. shift. The 5-ton tractor also brought in trees to the camp at noon and night, so that about 60 trees per shift were delivered.

Five teams of four horses each were used at first and their best record was seven trees per team or 35 trees for all teams in a 10-hr. shift. The saving in cost by the use of tractors is estimated at 50 per cent, but of greater importance was the saving in time for work of an emergency character. Teams were often delayed with heavy trees or in getting out trees which fell in such a way as to prevent getting a direct pull. But with the tractors these delays and troubles were eliminated.

In moving the hoisting engines, which was done at intervals of about ten days, the 10-ton tractor could do in two hours work which had taken two days with teams. Further, the tractors were used to tighten the

FROM JOB AND OFFICE

For Contractor and Engineer

cables or to drag out anchor cables which had become buried in the sand-bar built up by the action of the retards. Teams require regular periods of rest, but the tractors could work almost continuously. A 4-hr. interval at noon between the two 10-hr. shifts, was utilized for such service work as overhauling, cleaning, lubrication and supply of fuel, water and oil.

On this work at Dakota City a river frontage of seven miles is being protected by 20 current retards or permeable dikes in order to stop the erosion of valuable farming land, the farmers having co-operated in getting the work done for their common benefit. About 20,000 trees were required. The Woods Brothers Construction Co., Lincoln, Neb., was the contractor, with L. A. Day as superintendent in charge.

Time Cards Control Truck Haulage

CONTROL of motor trucks handling material excavated for pier foundations for the Hill to Hill bridge at Bethlehem, Pa., was effected through a simple though very efficient use of time cards. The Hill to Hill bridge being constructed by the Pennsylvania Public Service Commission spans not only the Lehigh River but four principal railroads, the Lehigh Canal and Navigation Co.'s canal and seven streets. Though the main structure is only about 2,000 ft. long with its three approaches and its four approach ramps this length is extended to about 6,000 ft. It is of reinforced

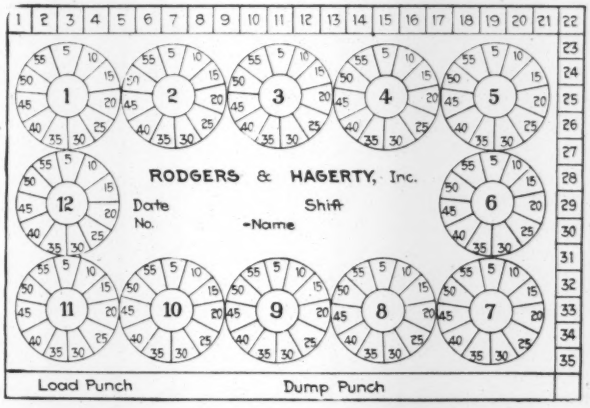


FIG. 1—TIME CARD FOR MOTOR TRUCK CONTROL

By punching the dial at loading point and dump an accurate time check is kept of all truck movements. Horizontal and vertical figures record trips per day.

concrete with piers of massive design and its spans range in length from 100 to 150 ft. c. to. c. of piers.

In excavating at piers it was necessary, because of the narrow right-of-way given the contractor, to dispose of material as excavated. Eighteen motor trucks were used to transport the excavated material from pier sites to the dump located at an average haul of a quarter of a mile from the bridge. The contractor organized a separate trucking concern and appointed a manager to oversee the work of the eighteen trucks that were kept in practically continuous operation.

The foremen on the job were required to tell the manager of the truck department every evening what the truck needs for the next day would be. The value of beginning to operate trucks early in the working day was realized, so no truck was allowed to go on the job after ten o'clock in the morning. This induced all job foremen to size up their needs of each succeeding day at the end of the day's work.

Time Cards—Actual control of truck movements was effected by the use of the time card reproduced in Fig. 1. The circles represent hours of the day. The line of numbers at the top and right of the card was for

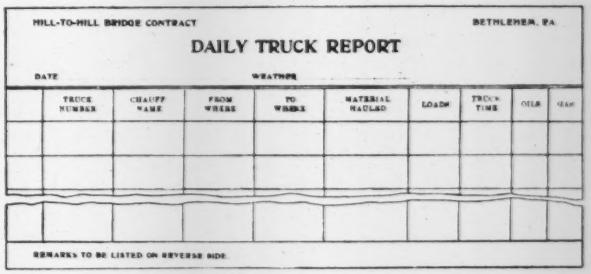


FIG. 2—FORMS USED ON MISCELLANEOUS HAULAGE

No check was kept on individual truck consumption of oil and gas. Total bills for these items were pro-rated monthly among all trucks continuously operating.

noting the number of trips made from the loading point to the dump. The cards were used as follows:

At each loading point and at the dump were checkers with punches that identified them with particular places. The driver of each truck was given one of these cards as he left the garage in the morning. When he arrived at the loading point the man there with the punch punched opposite "Load Punch" on the card and then the hour and minute of the driver's arrival. As the driver left with his load the man at the loading point punched out the first figure in the horizontal line of figures indicating that the driver had left with his first load. When the driver arrived at the dump the man there left his distinctive punch in the space opposite "Dump Punch" and then also punched the hour and minute of the driver's arrival at the dump. This process was repeated with each trip.

At the end of the day it was possible to check the activities of each driver by looking over his time card. The number of trips made was therefore indicated both on the hour and minute circles and in the horizontal and vertical columns. If the drivers card showed much fewer trips than the average for all trucks both he and the manager of the truck department were called on the carpet.

Besides the trucks on regular run several were used from time to time for miscellaneous jobs. To record the movements of such trucks another report was made out by the driver. That type of report is reproduced in Fig. 2.

In actual excavation a small steam shovel was used first before any sheeting was placed. After having dug down about 10 or 15 ft. bracing and sheeting was placed and the rest of the excavation was done by clamshell, handling the material direct from pier to trucks without any intermediate dumping board. All the material was taken to one dump. Excavated material is to be used in backfilling; and it is probable that considerable borrow will be used in addition.

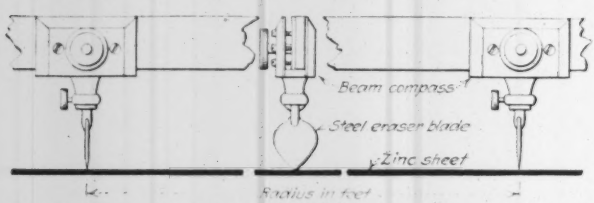
The bridge is being built by the Pennsylvania Public

Service Commission, of which Dr. Frank Herbert Snow is chief engineer, under the local supervision of the Bethlehem Bridge Commission. Clarence W. Hudson, New York, designed and is supervising the erection of the bridge. Rodgers and Hagerty are the contractors, with W. Caccia in charge for the firm as resident engineer, and George Angel as general superintendent. H. J. Finebaum is the representative of Mr. Hudson on the job, though Mr. Hudson is in frequent contact with the work himself.

Making Curve Templets

By Emile Low
U. S. Assistant Engineer, Buffalo, New York

REFERRING to the article "Making Curve Templets of Pressboard," *Engineering News-Record*, Aug. 24, p. 306, I have for many years used curves made of oil board, such as used in letter copy books. These I cut by means of a beam compass, usually to a scale



BEAM COMPASS FOR CUTTING CURVE TEMPLETS

of 200 ft. to the inch for even degrees and five- to ten-minute intervals. To cut the curves it is also necessary to have an old-fashioned steel eraser blade. A drawing table is the best surface to cut the curves on, having a piece of zinc where the curves lie. Cutting them with a sharp blade is much better than scribing from a metal set and trimming with shears. When well done the edges are not rough, but absolutely smooth.

Cable Guard Rail on Pennsylvania State Highways

WITH large wooden posts painted white above a black base, cable guard rail as illustrated gives excellent visibility on Pennsylvania highways. A ¾-in.

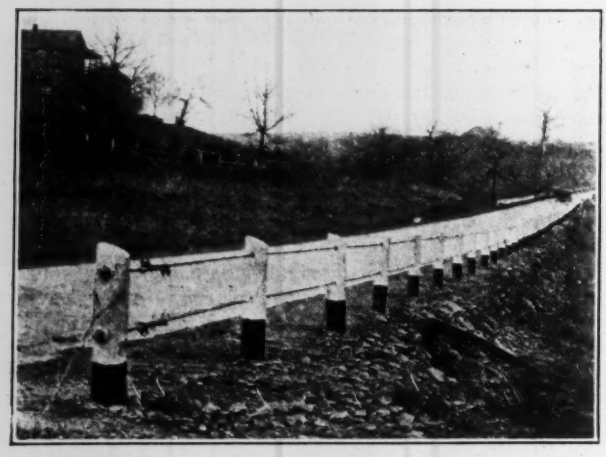


FIG. 1. WIRE CABLE GUARD RAIL PENNSYLVANIA

FROM JOB AND OFFICE

Hints That Cut Costs and Time

standard galvanized wire cable is used, threaded through intermediate posts and fastened to the end posts by eye-bolts provided with washers, nuts and long threaded shanks. The cable is strung with a block and tackle and tightened by means of the eye bolts. The end posts, as shown, are anchored against the pull of the cables by means of a ground anchor and a 12-wire

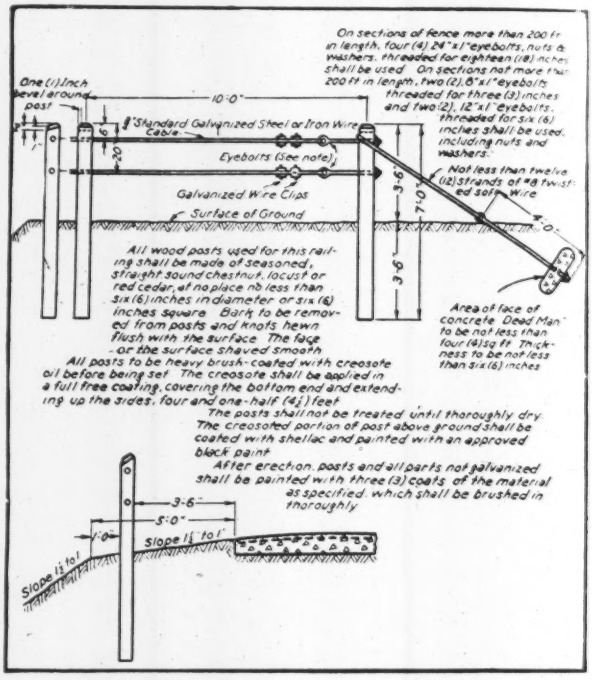

On sections of fence more than 200 ft in length, four (4) 24"x1" eyebolts, nuts & washers, threaded for eighteen (18) inches shall be used. On sections not more than 200 ft in length, two (2) 8"x1" eyebolts threaded for three (3) inches and two (2), 12"x1" eyebolts, threaded for six (6) inches shall be used, including nuts and washers.
One (1) inch bevel around post
10'-0"
¾" Standard Galvanized Steel or Iron Wire Cable
Eyebolts (See note)
Galvanized Wire Clips
Surface of Ground
Not less than twelve (12) strands of #9 twisted soft wire
All wood posts used for this railing shall be made of seasoned, straight sound chestnut, locust or red cedar, at no place nb less than six (6) inches in diameter or six (6) inches square. Bark to be removed from posts and knots hewn flush with the surface. The face of the surface shaved smooth.
All posts to be heavy brush-coated with creosote oil before being set. The creosote shall be applied in a full free coating, covering the bottom end and extending up the sides, four and one-half (4½) feet.
The posts shall not be treated until thoroughly dry. The creosoted portion of post above ground shall be coated with shellac and painted with an approved black paint.
After erection, posts and all parts not galvanized shall be painted with three (3) coats of the material as specified, which shall be brushed in thoroughly.
Area of face of concrete "Dead Man" to be not less than four (4) sq ft. Thickness to be not less than six (6) inches
3-6"
5'-0"
1'-0"
Slope 1:1 to 1'
Slope 1:1 to 1'

FIG. 2. WHITE PAINTED POSTS GIVE VISIBILITY

twisted cable looped around the post. The drawing gives all essential details of the structure and the view shows how clearly the railing stands out to the eye of the passing driver.

Old Band Saw Makes Expansion Joint Holder

An expansion joint holder made from and old band saw by slotting the saw and bolting it to a 2 by 4-in. piece of lumber was used by the Grays Harbor Construction Co., of Hoquiam, Wash., in a concrete street-paving job, according to the *Concrete Highway Magazine*. The saw was attached to the 2 by 4 which extended over the entire length of the saw and beyond it over the side forms. At the top of the joint holder and placed about 3 ft. apart were fingers made of short flat iron bars so fastened that they could be turned up and out of the way while the elastite was being placed against the joint board. They were turned down over the elastite to hold it in place. The device was held in place by means of round iron bars so bent that one end hooked over the 2 by 4 and the other end, sharpened to a point, was driven into the side forms. Iron pins driven into the subgrade helped to hold the device firmly in place.

FROM JOB AND OFFICE

For Contractor and Average Engineer

Two Curve Problems Solved

BY GEORGE F. SYME

North Carolina Highway Commission, Raleigh, N. C.

THE two problems presented below have recently been submitted to me for solutions. The first deals with the replacement of a tangent connecting two curves in the same direction with a third curve, the second deals with the widening of a pavement on the inside of compound curves.

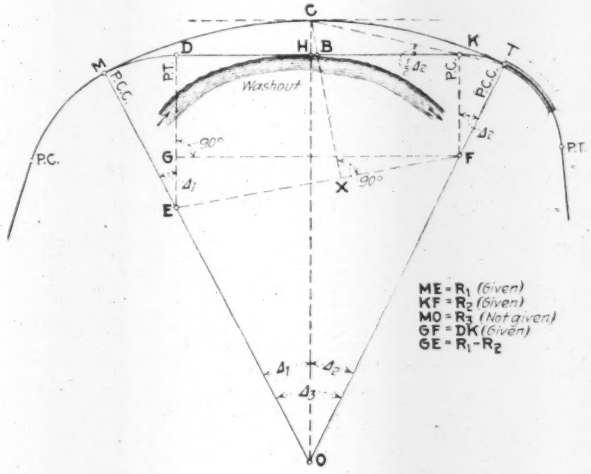


FIG. 1. PROBLEM IN RAILWAY LOCATION

Given: Two curves (Fig. 1) in the same direction, connected by a tangent $D K$ of known length.

Required: To replace the tangent with a third curve which shall begin at some point M, on the first curve and fall tangent to the second curve at a *fixed point*, T.

Solution: Draw the curve $M C T$. Join centers E and F, draw $F G$ perpendicular to $E D$, bisect tangent $D K$ at B, draw $B X$ perpendicular to $E F$, produce $B X$ to cut large curve at C, and join C and O. A tangent through C will be parallel to $D K$, and $C O$, $D E$, and $K F$ are then parallel. Draw chord $T K C$, then $\angle T F K$, $(= T O C = \Delta_2)$, is known, because point T is fixed.

(1) Solve right triangle $E G F$ for side $E F$ and for $\angle s E F G$ and $G E F$. Then $\angle H C B = \angle E F G$ and $\angle C B H = \angle G E F$.

(2) In triangle $K B C$, $\angle C K B = \frac{1}{2}\Delta_2$ and $\angle C B K = 180° - \angle G E F$. Then $\angle K C B = 180° - (\angle C B K + \frac{1}{2}\Delta_2)$, and $B K = \frac{1}{2} D K$, which is known.

Then $$K C = B K \frac{\operatorname{Sin} C B K}{\operatorname{Sin} K C B}.$$

Chord $T K = 2 R_2 \operatorname{Sin} \frac{1}{2}\Delta_2$, and chord $T C = T K + K C$.

Then $$O T = R_3 = \frac{T C}{2 \operatorname{Sin} \frac{1}{2}\Delta_2}$$

Now in triangle $O E F$, side $E F = \sqrt{E G^2 + G F^2}$, $O E = R_3 - R_1$, and $O F = R_3 - R_2$

Now knowing the three sides of triangle $O E F$ we have, where $S = \frac{1}{2}$ the sum of the three sides,

$$\operatorname{Sin} \tfrac{1}{2}\Delta_3 = \sqrt{\frac{(S - OF)(S - OE)}{OF \times OE}},$$ from which we find Δ_3.

And $\Delta_1 = \Delta_3 - \Delta_2 =$ the angle required to back through on the first curve, to locate the point M. The large curve will fall tangent to the second curve at T.

The problem in widening pavements on the inside of compound curves, by connecting the two inside arcs with a third circular curve is as follows:

Given: A two-centered compound curve, Fig. 2 (with complete curve data), on the center line of a pavement W feet wide.

Required: That the pavement be widened on the inside of the curve by means of given transition spirals and circular arcs.

Solution: Select the proper spiral for each end of the curve, and note that there results an offset, $B C$, on the inner edge of the widened pavement. To eliminate this a third curve, $P S L$, is desired.

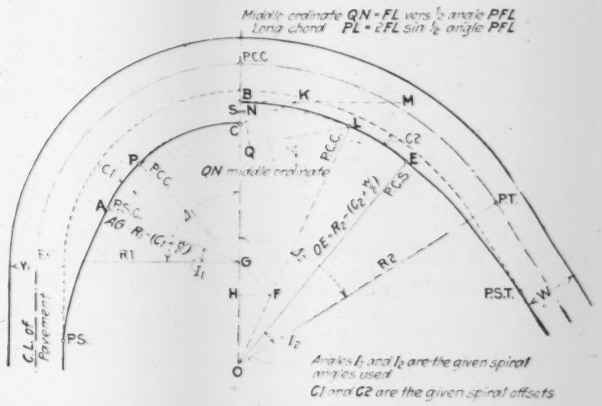


FIG. 2. WIDENING PAVEMENT ON COMPOUND CURVE

Draw the above figure, making $B M$ perpendicular to $O B$ at B. Note that line $P C K$, through point C, cuts $B M$ at K. Assume an angle as $C G P$, which locates P.

Then $$\angle B C K = \frac{180° - \angle C G P}{2},$$ and $B K = B C \tan \angle B C K$, where $B C$ is the difference between the given radial offsets C_1 and C_2.

Tan $\frac{1}{2}\angle B O L = \frac{B K}{O B}$, hence $\angle B O L$, which locates the point L.

Now $\angle P F L = \angle s B O L + C G P$, = the central angle of the required curve.

In triangle $G F O$, we have $O G = O B - (G C + B C)$, and $$G F = \frac{O G \operatorname{Sin} B O L}{\operatorname{Sin} (180° - \angle P F L)},$$ then the radius of the required curve $P S L = F P =$ the given radius $G P + G F$.

The long chord $P L$ may be easily computed and used as a check on the field work, and ordinates to any desired point on the curve $P S L$ may also be computed.

The above problem may also be solved by assuming a radius $F P$, greater than $G P$ but less than $O B$. In this case we solve the triangle $G F O$, in which all sides are known, for $O F$ and $F G$ are radial differences and $O G = O B - (G C + B C)$, as before.

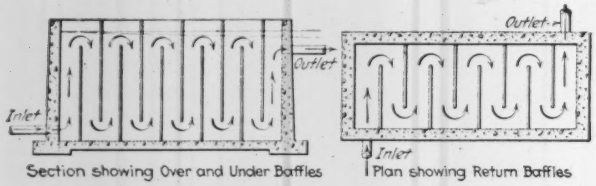
In practice it is sometimes advisable to make two or more solutions of the problem based upon different assumptions, and to select that curve which best fits local conditions.

LETTERS TO THE EDITOR

This department aims to be a forum for the discussion of the views of engineers and contractors. The range of interest should be as wide as possible. Contributors are, therefore, asked to make their letters short.

Computing Loss of Head Through Baffles in Mixing Chambers

Sir—Will some of your readers kindly give the proper method of computing the loss of head through over and under baffles and through horizontal baffles in mixing chambers, as shown by the accompanying illustrations, giving the formula used for computing this loss. P. B. S.



Considering Foreign Woods to Resist Borers

Sir—I have been much interested in reading in *Engineering News-Record* of Oct. 12, pp. 619 and 626, an article on the service obtained from greenheart on the Panama Canal and also Mr. Kooy's communication. The Marine Piling Investigations Committee of the National Research Council are in no way overlooking the possibility of using foreign timbers. We have collected considerable data through various sources, most of it from the Forest Products Laboratories, at Madison, Wisconsin. We have a service record or a record of tests for greenheart as follows:

In the British Isles we have record of eighteen different ports in which greenheart was used. In several Scotch ports this timber is reported to have been heavily attacked in from eleven to fifteen years—in one case it was destroyed in four years. In England the results are somewhat varied. Slight attack is reported on ten years service and in two cases, complete destruction in twenty-five to thirty years, while at other points perfectly sound timber is reported which has been in service as high as fifty years.

Reports from Holland, Belgium and France show service ranging from three to twenty-nine years. In no case is the attack reported as more than slight. One installation in the Mediterranean was reported as destroyed in twenty years. In South Africa very heavy attack in eight years is reported. In three out of four cases in Java and India the timber was destroyed in from ten to twenty years, while in the fourth case, heavy attack was reported in ten years. Trinidad reports complete destruction in fifteen years and Georgetown, British Guiana, in twenty to twenty-five years.

The Forest Service placed a test piece at Pensacola, Florida, which was very heavily attacked in seven years. In this case, the attack of the teredo type of borer was apparently light and the heavy damage was done by martesia.

Definite conclusions cannot be drawn from these records, but there is some reason to think that in northern harbors, at least, greenheart may be expected to give fairly long service.

The records of service of jarrah mentioned by Mr. Kooy are not so good. There are only four reports from England; three of them show timber in good condition after sixteen to twenty years service and one of them shows heavy attack after twenty-four years service. South and East Africa report twelve cases, only one of which shows the timber in good condition after twenty years' service and most of them show it destroyed under twelve years. One test shows it destroyed in six months. Reports received from Arabia, India and Ceylon all show timber heavily attacked or destroyed in from fifteen months to six years. Japan shows destruction in two and a half years. The Australian ports which have used this timber to a considerable extent show quite variable records. Some of them show long service, but from other information it appears probable that the borers were not very active at these points. In one New South Wales harbor total destruction is shown in six and one-half years, while in one case in Victoria seven years service was obtained with only slight attack.

Information has been collected by the committee covering a number of other foreign timbers, and arrangements are being made to test some of them in American harbors. It is entirely possible, as Mr. Kooy suggests, that some of these timbers may be found of value for port work in the United States. They will, however, undoubtedly, prove to be expensive.

WILLIAM G. ATWOOD,
Director National Research Council.

New York, Oct. 17.

Testing Hollow Building Tile

Sir—In your issue of Sept. 7, p. 396, William B. Newhall, consulting engineer for the Northwestern Clay Products Co., discusses some very important points to be observed in testing hollow tile, in particular the method of applying the load and the rigidity of the bedment of plaster. Undoubtedly the methods considered by Mr. Newhall are efficient. They will give good test results at little if any additional expense. However, it is not always expedient to add portland cement to the bedment plaster in the case of a busy laboratory on account of the time required for setting.

I should be glad to put in evidence my own views at this time as to how we can most efficiently proceed with this rather new and valuable structural material. One point refers to the structural design of tile, the others to the methods of tests. The writer arrives at his conclusions in connection with a long experience in testing tile and other material at the U. S. Bureau of Standards, together with experience since then with raw clays.

1. A beam or diaphragm such as the web of a tile is weakest at the ends or points of juncture with the other material, there being no transverse forces intermediate. The theory of secondary stresses well known to engineers shows that a free beam without transverse loads has its internal stress couple a maximum (or a minimum) at the ends or juncture points. Now it will be clear there is scarcely any filleting given by the manufacturers at the re-entrant angles. A ¼- or ½-in. radius fillet could be easily supplied in the dies at little expense. They should be supplied for the same reason a pattern-maker supplies them in a pattern for a casting. There is sometimes a shrinkage crack coincident with the re-entrant angle, an additional weakness. Stress theoretically tends to largeness at this point even when the cells are vertical in the testing machine. Moreover, the tiles frequently fail just at these points. The weakness is developed *a fortiori* when the tile is bedded with the cells running horizontal. If the web were bellied very slightly in addition to the larger filleting of the re-entrant angles, some additional strength might be added, but this point is not as important as the filleting. This filleting is important for the same reason as gusseting a garment or supplying a frame with cross-braces at the corners. Practically, the tendency to infinity of stress is eliminated by this means. It presents no practical difficulty to the manufacturer and will greatly enhance the value of his product as regards strength.

2. In making compression tests the applied stress should be a uniform compression without bending couples or platen frictions introduced by the testing machines as the result of any eccentricity. Mr. Newhall proposes an improvement on the older form of a hemispherical block. While, however, his method tends to eliminate eccentricity, it does not prevent rotation of the surface plate which may be brought into play as a result of inherent heterogeneity in the material, unequal compression of the bedment of plaster, or

imperfect ends. It would seem that the desideratum to be attained is some sort of a hydraulic bearing which would insure the application of a uniform compression stress to specimens, eliminating eccentricity of loading, rotation and bending, and the necessity of a bedment mortar. It is true that thousands of concrete cylinders are tested by the older hemispherical block method. This, however, is only another instance of the persistency of what might be designated the law of the survival of the unfittest. If uniform compressions were applied to concrete cylinders undoubtedly the relatively wide bands of data now characterizing the various stress relations found in connection with different methods of proportioning concrete would be narrowed, with much smaller deviations from the mean curve. The same observation would hold in the case of tiles or other compression pieces.

The hydraulic bearing is not wholly untried. Gardner S. Williams and C. J. Tilden used one form in beam tests at the University of Michigan—a box or chamber with an inner rubber casing holding water which was subjected to compression. The chamber was open on the side next the upper flange of the beam where loads were applied. Egress and rupture of the casing or inner tube was prevented by a sort of corseting of small steel slats resting in juxtaposition on the flange of the beam, this also eliminating flexural effects and variability of pressure. Dean Marston has applied a simple hydraulic bearing to testing drain tile, using merely a short length of fire hose with sealed ends, partially filled with water. This readily adapts itself under pressure to the rough surface of the tile. Perhaps the best form of bearing for compression pieces would be a development of a type once used by Mont Schuyler and discussed by him in a paper before the A.S.T.M. in 1913. He secured a uniform or hydrostatic pressure simply by the use of an inner chamber in the bearing head, this being separated from the faces of the specimen by a flexible diaphragm having practically the same diameter as the former. With this type when perfected a true hydrostatic pressure can be secured without bedment of plaster or cement.

3. Mr. Newhall states in his third point: "Only those tests that make the vertical webs fail in diagonal shear can be said to have properly developed the strength of the tile." This, of course, is the common view as regards compression failures. The writer, however, is of the opinion that this is only to be regarded as an inference. Brick piers have vertical planes of failure, the diagonal planes being confined to the ends as the result of local effects due to the bracing of the pier structures by lateral platen frictions. The writer is under the impression that the change from flatwise to edgewise tests of brick in compression as proposed by the A.S.T.M. specifications (C21—20) was made solely for the purpose of eliminating platen frictional bracing of the brick. Some authorities are in favor of a test on end. Mont Schuyler's tests on concrete under uniform compression show that the cylinder breaks into three pieces separated by vertical planes 120 deg. apart. I have found likewise that this is the common type of failure with rock for road material tests with the Page impact machine. I have found moreover that in the case of fairly uniform compression stress amorphous materials such as clays break up into septaria or honeycomb structures, the prisms' planes being still 120 deg. apart as in the case of Mont Schuyler, his case apparently being particular as a result perhaps of relatively small cylinders being used. I believe that the behaviors cited are akin to crystallization. The behaviors in natural clays might in fact easily pass for shrinkage failures in drying out—they are so similar, were they not obtained by direct compression through many tests. Physicists with whom I have discussed these phenomena think the analogies are favorably supported by the test results. I will proceed to discuss the phenomena as they appear in the case of tile tests.

4. A test should be arranged to develop the intrinsic strength, i.e., the maximum possible strength of the material, whether this be in the form of a hollow tile, a concrete cylinder, brick, or steel column. A rigorous test of his material is due the manufacturer.

If it is desired to obtain the maximum possible strength of hollow building tile, then in addition to the use of a hydraulic bearing of the Schuyler type it might be well to consider omitting a bedment plaster altogether where great refinement is desired and, instead, grinding the ends of the tile square with the axis on a surface grinder. This would be necessary for tile but not concrete. A Dorry type of grinder—a steel disk revolving horizontally at a moderate number of revolutions to which sand is fed—will suffice for surfacing the ends, the weights of the tiles placed on the disk maintaining sufficient pressure for expeditious surfacing. When the tiles thus surfaced are tested even with a hemispherical block method of applying the load the compressive strength developed is much larger than in the case of plaster bedments. From memory, values of 12,000 to 14,000 lb. per square inch were found. The failures in this case were not of diagonal shear type. There were no initial reports or partial failures. Instead the tiles failed like the one hoss shay, with a single final collapse, elastic limit and ultimate being identical. The pieces broke at the re-entrant angles into a series of webs and side strips. This type of failure for openwork structures would seem to be strictly comparable to the net work of prisms occurring in the case of brick piers, Schuyler's cylinders or rock tested in the Page impact machine. If the re-entrant angles were filleted as has been suggested and it were possible to adopt some efficient hydrostatic bearing block for the standard compression test, it is not improbable that still higher results might be obtained than were reported.

It is of course a question whether the points mentioned are worthy of consideration to the exclusion of others commonly designated as "practical." I am under the conviction that the intrinsic strength of a tile is above the apparent strength developed by ordinary test methods. Accordingly in formulating a standard test every effort should be given to rigor of performance to insure that the data obtained denote the real strengths attainable and are not in effect mere apparent values conditioned by the contingencies of observation and not truly representative of the quality of the material. The paper by Mr. Newhall emphasizes some of the important factors to be considered. I am in hearty agreement with the plea of his last paragraph.

J. H. GRIFFITH,
Department of Civil Engineering,
Iowa State College.

Ames, Iowa.
Sept. 20.

Wyoming Rock Prices

Sir—In *Engineering News-Record*, Aug. 10, p. 232, is an article on "The Southeast Corner of Wyoming," by W. W. DeBerard, in which the Wind River Road is mentioned. He makes the following statement: "On the 13½ miles in the contract recently let to the Utah Construction Co., 11½ miles must be carved out of the solid rock, making 94 per cent of the excavation rock (284,000 cu.yd.). Incidentally, this road will be the main route to Yellowstone Park. Contractors will be interested to know that the solid rock excavation went at 68½c. per cubic yard, a decidedly low figure under the circumstances." This is an error and should be corrected. As a matter of fact on section B, a solid rock job, the Utah Construction Co. bid $1.50 per cubic yard, on section C, a mixed earth, loose rock and solid rock job which was unclassified their bid was 70c. per cubic yard.

E. F. STEVENS,
Stevens Bros.,
Contractors.

St. Paul, Minn., Sept. 2.

[C. C. Warrington, deputy state highway engineer, writes that the $1.50 price for section B is correct but that the contractor is being paid 68½c. for section C, as given in the article and 18c. for section D, earth excavation largely.

The work on this project was divided into three sections in order to conform to the various classes of excavation and bids were requested for unclassified excavation on each section. The rock on section B consists of diorites and granites in solid ledges. The rock on section C are the sedimentary lime and sand stones in ledges and in slides. EDITOR]

NEWS OF THE WEEK

New York, October 19, 1922

Group Meetings to Feature Highway Program

No General Sessions at State Highway Officials Convention While Subcommittees Are in Session

Principal emphasis will be placed on group meetings at the eighth annual meeting of the American Association of State Highway Officials, which will be held at the Baltimore Hotel at Kansas City, Mo., Dec. 4, 5, 6 and 7. No general sessions will be held during the time that the group or subcommittee meetings are in progress. These subcommittee discussions will cover plans and surveys, design, specifications, traffic control and safety, bridges and structures. The subcommittee discussions are scheduled to take place during the afternoon of Dec. 4. Regular meetings also are scheduled for the full committees on administration, construction, motor-truck regulation, maintenance, standards, tests and investigations and publications.

DETAILED PROGRAM

At the opening session, in addition to the address of welcome and the annual address of President C. M. Babcock, of Minnesota, there will be a formal paper on "Troublesome Problems Encountered in the Administration of a State Highway Department," by A. R. Hirst, the state highway engineer of Wisconsin.

W. S. Keller, of Alabama, will preside at the general session on Dec. 5. Addresses will be given by A. B. Fletcher, state highway engineer of California, on "Financing Construction and Maintenance on a State Highway System," and by Clifford Older, chief highway engineer of the Illinois Department of Public Works, on "The Service Test of the Bates Road—A Step Toward the Rational Design of Roadway Surfaces." T. E. Stanton, the assistant state highway engineer for California, will present tentative conclusions on the design of pavement sections derived from studies of the effect of traffic on the Pittsburg, California, test road. An evening session will be held on Dec. 5 to consider matters pertaining to bridge design. The principal paper will be presented by L. N. Edwards, bridge engineer, Maine State Highway Commission. C. N. Connor, the assistant engineer of the North Carolina commission, and C. B. McCullough, bridge engineer for the Oregon commission, are scheduled to present remarks on the subject.

At the morning session on Dec. 6, Thomas H. MacDonald, chief of the U. S. Bureau of Public Roads, will discuss the functioning of the federal-aid policy. Rollen J. Windrow, the consulting engineer to the Missouri highway commissioner, will present the handling of federal aid from the state point of view.

There will be an afternoon session on Dec. 6 at which John H. Mullen, deputy commissioner of highways for Minnesota, will present a paper on "A Construction Division—Its Financing, Organization and Operation." G. C. Dillman, Deputy Commissioner of the Michigan State Highway Department, will address the same session on "The Field Control of State Highway Maintenance Work."

Officers will be elected and committee reports received at a morning session on Dec. 7.

Philadelphia Awards Contract for 280-Ton Incinerator

A contract for a 280-ton incinerator for mixed garbage and rubbish, to be located in the northeast section of Philadelphia has been awarded to the C. O. Bartlett & Snow Co., Cleveland, Ohio, in accordance with its recent bid of $145,200 for four furnaces in one plant, including all auxiliaries. Three other bids, all informal in some respects, were received. *Engineering News-Record* is officially informed that the plant proposed by C. O. Bartlett & Snow Co., met every requirement of the specifications, and that the company was able to show a plant of approximately the same capacity in successful operation on this continent for five years, practically of the same design and construction as called for in the city specifications. The furnace selected is of the Sterling type, with four grates to each furnace. No effort will be made to produce steam as a byproduct of the destructor. Frank H. Caven is director of public works of Philadelphia; Fred C. Dunlap is chief of the Bureau of Highways, and John H. Neeson is deputy chief in charge of street cleaning.

Road Builders' Convention Session to Be Separate From Exhibits

Radical changes have been made in the program for the thirteenth American Good Roads Congress and Fourteenth National Good Roads Show to be held in Chicago, Jan. 15-19, 1923. Instead of holding sessions at the Chicago Coliseum, where the show will be housed, they will be held at the Congress Hotel. It is believed that this will insure a better attendance as noises heretofore so disturbing to the speakers and convention delegates will be eliminated.

Another feature of the program of the American Road Builders' Association is the fact that controversial subjects will not be avoided this year as heretofore, and, according to C. M. Upham, chairman of the general arrangements committee, the program will consist of controversial subjects of vital interest to the whole roadbuilding industry.

The exhibits committee has employed a professional director of exhibits and the publicity committee, an experienced publicity man.

New York Engineers Discuss Structural Safety

Diverse Opinion Expressed as to Responsibility; Resolution to Study Subject Further Passed

Methods of bringing about greater assurance of structural safety in buildings of public assembly were discussed at a meeting of the New York Section of the American Society of Civil Engineers on Oct. 18. Divergent opinions were expressed, but the meeting finally voted in favor of further study of the subject by a committee.

James B. French, consulting engineer, introduced the subject with a sketch of existing conditions as revealed in the failure of the American Theater in Brooklyn and the Knickerbocker Theater in Washington, last December and January, and presented a resolution originally introduced last spring before the structural sub-section of the New York Section. This resolution (*Engineering News-Record* of August 31, 1922, p. 351) proposed legislation to require that before any building of public assembly be opened its safety to be certified to by a competent structural engineed. Mr. French made a strong argument in favor of this resolution, taking the position that no other method will suffice to eliminate the risks arising from incompetent design or bad construction or erection.

OTHER OPINIONS

Rudolph P. Miller, consulting engineer and former superintendent of buildings at Manhattan Borough, spoke in favor of governmental control of the responsible heads of building operations. Such regulation was proposed by him some years ago, and has been introduced as a bill before the last two legislatures of New York State. It failed in both sessions, however, although a bill to license brokers was passed without difficulty; he referred to the difference as illustrating the ease with which legislation involving money matters goes through, as contrasted with safety legislation. L. F. Pilcher, state architect, attributed the failure of this bill to inadequate presentation of the arguments in its favor to the proper parties, and asserted broadly that any bill that is properly presented is sure to obtain the necessary support for passage. However, he charged broadly that it is impossible to card-catalog or to mechanize honesty or responsibility, and presented the view that the personal care and responsibility of either architect or engineer or both in combination is fundamental to the success of any construction operation. Experiences of New York state in constructing institutional buildings illustrated this argument. Mr. Pilcher's main emphasis was on harmonious cooperation of engineer and architect, with either the architect or the engineer responsible, depending on circumstances.

Daniel T. Webster, manager of Marc Eidlitz Sons, contractors, upheld the

view that the engineer is necessary to a large construction job, and that his responsibility and supervision should attend upon the job throughout, until its completion, at which time he is capable then of certifying the safety and adequacy of the construction. Sound practice in this respect should be enforced by the society, and the society should also set up a sub-committee to deal with problems arising in construction relations and gradually build up a code of practice. Lewis D. Rights, contracting engineer of the Shoemaker-Satterthwait Bridge Co., reviewed the change in commercial conditions in the structural field, from design by fabricating companies to design principally by independent engineers, and pointed out that the manufacturers desire generally to eliminate engineering service from their work and confine themselves to construction. He opposed the French resolution, however, on the ground that the responsibility for the structural safety of a building should rest upon the owner, not upon the engineer. He moved that the resolution be referred to a sub-committee of three for report. This proposal was adopted by the meeting. Another suggestion made in the course of the discussion, to the effect that the owner of any building under construction should be required to give bond for its safety, so that bonding interests would undertake the determination of safety, was not acted upon.

At the same meeting an interesting sketch of the Alsatian Rhine navigation canal project was presented by M. Antoine, an engineer of the French Government. This project, which has been in existence in some form for twenty years or more, has recently acquired definitive status by an international agreement of the states bordering on the Rhine. In connection with the navigation improvements which this canal will bring about, nearly half a million horsepower will be developed.

Motion pictures illustrating the Catskill aqueduct were shown as an introduction to the meeting. The section has adopted the plan of opening each meeting with motion pictures, to bring about an early gathering and thereby make is possible to terminate the meetings earlier in the evening.

Roads Bureau College Planned

The establishment in Washington of a Bureau of Roads College, somewhat along the lines of the Army War College, is regarded by Thomas H. MacDonald, Chief of the Bureau of Public Roads, as a desirable step to keep practising highway engineers abreast with progress in the art. The college would be planned so as not to conflict with established educational institutions. It would not be a post-graduate school. The idea is to provide short courses largely for the benefit of experienced engineers. There is ample opportunity, Mr. MacDonald thinks, for more work on the scientific side of road building. The study of the physics of road building materials is not keeping pace with the science of their application. For that reason Mr. MacDonald attaches importance to the arrangements already made for a series of lectures by Dr. W. A. Patrick of Johns Hopkins University on the physical chemistry of the colloids. These lectures will constitute a part of a series arranged by the Secretary of Agriculture.

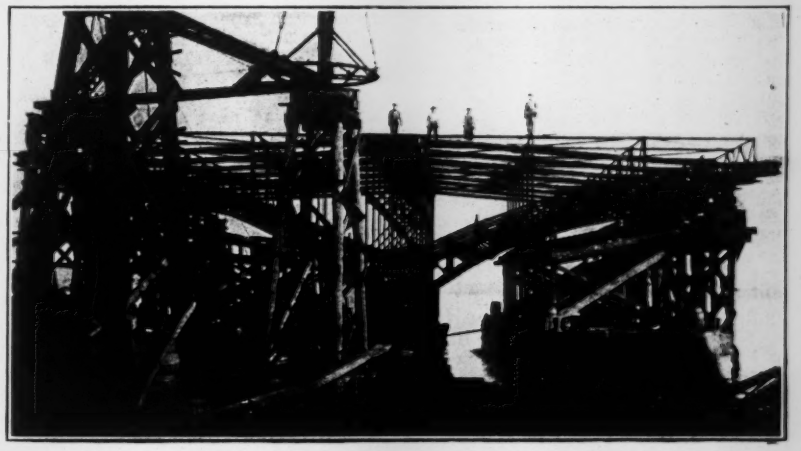
New Canadian National Board Appoints Executives

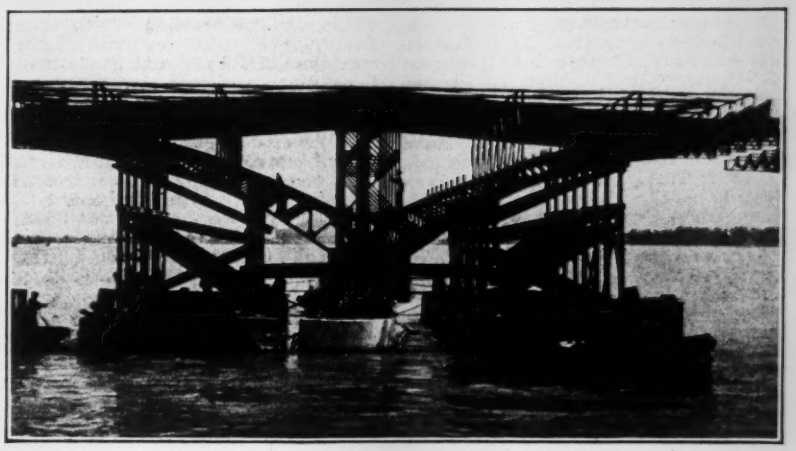
The first meeting of the new Canadian National Ry. board of directors was held Oct. 10, when Major Graham Bell, Deputy Minister of Railways, was appointed vice-president. S. J. Hungerford, who has been vice-president and operating general manager of the Canadian National lines (not including the Grand Trunk) was formally appointed vice-president and general manager of these lines. Both these appointments are temporary, pending the coming of Sir Henry Thornton from England.

W. D. Robb, vice-president and general manager of the Grand Trunk, has appointed D. E. Galloway as assistant vice-president of the Grand Trunk System; C. G. Bowker, operating manager on lines east of the Detroit and St. Clair Rivers; and C. Manning assistant manager on the same lines. Mr. Galloway was appointed assistant to the president in 1911 and occupied that position for several years.

Would Consolidate Colleges in Canadian Maritime Provinces

A proposal has been made to consolidate all the colleges in the three Canadian maritime provinces in one federated university. This would include the engineering schools conducted by the colleges. At present, the following maritime province educational institutions have engineering schools or departments: Dalhousie University, Halifax; University of New Brunswick, Fredericton; St. Francis Xavier University, Antigonia; Mount Allison University, Sackville; St. Dunstan's University, Charlottetown; Nova Scotia Technical College, Halifax; Acadia University, Wolfville; and King's College, Windsor. The proposal for one big engineering school has been received with favor by many of the graduate engineers of the maritime provinces although there has been exhibited a difference of opinion over the advisability of discontinuing such long established engineering schools as that of the University of New Brunswick.





NOVEL STEEL-ERECTION METHOD USED AT BELLE ISLE BRIDGE

As outlined in *Engineering News-Record* of July 27, p. 149, an interesting floating-in procedure is followed in placing the steel frames of the arch-shaped cantilever spans of Detroit's monumental concrete bridge which will cross the west arm of the Detroit River to connect with the public park on Belle Isle. Each unit comprising two half-cantilever frames and the pier tower from which they spring is erected on shore, some distance away from the bridge site, where falsework for supporting the arms is provided. Then two scows carrying adjustable timber bents are floated under the arms (upper view), are pumped out to raise the steel frame off the falsework, and are then towed to the bridge, where the steelwork is easily lowered to its seat on the pier by flooding the scows. In the lower view the frame is seen approximately over the pier, being pulled to correct position by mooring lines. The work is being done by the Wisconsin Bridge & Iron Co. under the direction of Esselstyn-Murphy, engineers.

Warren Bros. Co. Wins Paving Patent Suit

A decision in favor of Warren Bros. Co., of Boston, in its suit against Oscar Huber, contractor, involving 75,000 sq.yd. of paving in the State of Oregon laid prior to May 5, 1920, under the Warren company's then-existing bitulithic patents, was handed down Oct. 12 by Judge Bean of the United States District Court at Portland, Ore. The decision reaffirms other court decisions establishing the validity of the Warren company's basic patent No. 727,505 and establishes 25c. a square yard as a reasonable royalty.

This case involves work done several years ago before the Warren patent No. 727,505 had expired on May 5, 1920. The decision has nothing to do with the Wallace patents under which the Warren company is now operating and on which the Warren company recently lost a suit brought against Thompson Bros., in which the County of Fresno, Calif., was a co-defendant.

Of the Oregon case the court says: "The defense made in this case of anticipation by prior uses, prior patents and literature and double patenting is the same as those involved in prior litigation, either in fact or in kind. The evidence here does not show anything substantially new in respect thereto or any reason why the conclusion of such court should not be followed. . . .

"The defense of non-infringement is not made out. The pavements laid by the defendant under this contract with the State Highway Commission and involved in this suit are in all particulars the same as that previously laid by him and the Highway Commission upon which royalties were paid, and in my opinion are clearly infringements of plaintiff's patent. There is no dispute as to the yardage, 74,541.8 yd., and the evidence shows beyond question that 25c. a yard is a reasonable royalty."

Great Notch Tunnel Bids Opened

Several interesting features are noted in the comparison of bids for the construction of Contract 3 of the Great Notch tunnel and approaches for the North Jersey District Water Supply Commission. Five bids were submitted, the totals being as follows: Heyman & Goodman Co., Jersey City, N. J., $918,297; T. A. Gillespie Co., New York City, $978,543; Mason & Hanger Co., New York City, $1,158,441; Patrick McGovern, Inc., New York City, $1,208,285.25; and the Frederick Snare Corp., New York City, $1,386,025. Three lump sum bids were also submitted.

Rather an unexplainable situation is evident for removal of top soil, earth excavation in open cut, rock excavation in open cut, and refill and embankment. For these four items the low bidder bid $79,400 as against $417,510, the high bid for the four quantities. For earth excavation in tunnel the unit bids ranged from $9 to $29.50; for excavation of trap rock in tunnel, from $15.50 to $29.50; for excavation of sandstone in the tunnel, from $15.50 to $29.50, and for the enlargement of the tunnel in rock, from $11.35 to $28. Unit bids on concrete masonry in the tunnel were $9 for the low bid and $17.30 per cubic yard, the high bid. Cement prices ranged from $2.60 to $4.50 per barrel, with no two bids identical.

Model Bill Covering Day Labor Work Is Aim of A.G.C.

A model bill requiring that an accurate account be kept of construction work done by day labor and that this record be open to the public is to be drawn by The Associated General Contractors of America and a campaign for its adoption in each state, with such variants as may be necessary, will be started. The model bill will be framed along the general lines of the law in effect in Minnesota.

The provisions which it is desired to include in such bills are: the publication of the estimated cost of the work; receipt of bids; publication of final cost if finally executed by a public body by means of day labor; and accounting of cost, including expense of equipment, depreciation, repairs, engineering and other services and similar legitimate charges. The Minnesota law does not include receipt of bids.

It is the belief of the contractors' organization that a comparison of the cost of executing work through a public body with that of letting by contract will show that the former method is much more expensive.

The California legislature last year passed a bill of this character but it was vetoed by the governor. The bill, even more inclusive, will be introduced again at the next session of the California legislature.

Yakima-Portland Railroad With Branch Lines Is Proposed

In the filing of articles of incorporation for the Yakima Southern Ry. Co. at Olympia, Wash., a project involving the construction of 154 miles of railway from the Yakima district in eastern Washington to Portland, Ore. was announced. E. E. Lytle heads the company, which plans for its first unit the construction of an 86-mile railway, costing $5,000,000, to be built from Underwood up the White Salmon River and across the Cascade Mountains to Yakima. The work involves a one-mile tunnel. The road will have a maximum of 1.5 per cent grade. Additional lines projected are an extension from Yakima to Beverly, 38 miles, and another 35 miles between Ellensburg and Wenatchee. Another line, 35 miles long, from North Prosser to Paterson, is also projected. Traffic across the Columbia River into Portland will be handled by huge barges, equipped to convey the fruit shipments from the rich Yakima and Wenatchee districts.

Colonel Kelly Inspects Kettle Falls Power Site

Col. William Kelly, Corps of Engineers, U. S. Army, and chief engineer of the Federal Power Commission, recently inspected the Kettle Falls power site on the Columbia River in company with Col. Edward Schulz, district engineer for the Power Commission. They were accompanied on the tour of inspection by R. L. Hearn, hydraulic engineer for the Washington Water Power Co., the organization which recently was given a preliminary permit to develop the Kettle Falls property. Col. Kelly is on an inspection tour of proposed power developments on the Pacific Coast as shown by applications on file with the commission at Washington.

A.A.E. Provides for Membership in Chapter-at-Large

As a result of chapter referendum just completed on amendments to its by-laws, the dues of each member of the American Association of Engineers will become payable on April 1 of each year instead of on the anniversary of his being made a member; and the fiscal year of the association is changed from Jan. 1 to July 1. While the collection of dues on the anniversary of a membership date avoided any peak load, the confusion on the part of chapters and members outweighed this advantage in the judgment of the members as expressed in the referendum.

The amendment extending to any member the privilege of affiliating with the chapter-at-large was carried also by 2 to 1, and is of much greater significance than either of the other amendments carried. In effect, it permits any member to belong to the national association only. Heretofore all members were required to belong to a local chapter, with the result that those who moved about considerably or who were interested in the major national problems alone felt under restraint and became dissatisfied. The amendment as adopted reads:

> Article V, Section 5: There shall be a chapter-at-large with which any member may choose to affiliate and to which may be assigned by the board of directors foreign members who cannot properly be assigned to chapters. National officers shall be ex-officio officers of the chapter-at-large.

The proposed amendment providing for a nominating committee of three to be appointed by the board of directors to place in nomination two candidates for president, and first and second vice-presidents, with the privilege retained by the members of nominating by petition as at present, was lost.

Employees Liability Law Covers Typhoid in Michigan

An employee who contracts and suffers from typhoid fever due to polluted water furnished by an employer is entitled to compensation according to a recent decision of the Michigan Department of Labor and Industry. The commission noted that the sickness was an "accident" within the meaning of the law. While a number of similar cases have been before the commission the application for compensation, according to Ray Derham, deputy commissioner, has been denied because it has been impossible for the injured employee to establish the fact that he contracted the disease during the course of his employment. The Michigan Supreme Court has never yet passed on this specific question although it has decided on cases of influenza, anthrax and blood poisoning. In Dunwood vs. Royal Indemnity Co., 218 Michigan 358, the Supreme Court discussed this class of case at length. In that case a doctor was held to have suffered an accident when an influenza patient coughed in his face and the doctor contracted the disease as a result.

A number of years ago the Supreme Court of Wisconsin decided that the contraction of typhoid fever was an accident.

Work Resumed on Sacramento Filter Conduits by Day Labor

After considerable delay work has been resumed on the intake conduits from the river to the pumping station of the Sacramento water-filtration plant. The work is now being done by day labor. A review of the original contract, the controversy with the contractor, and the final settlement appeared in *Engineering News-Record*, Jan. 13, 1921, p. 77, and April 27, 1922, p. 711. The delay has been due (1) to a lawsuit involving the validity of the new city charter and, (2) when the charter was held valid and the contract readvertised, to a lack of formal bids on Sept, 7 and to the bids received on Sept. 19 being considered too high—three bids ranging from $158,777 to $187,490 compared with the engineer's estimate of $130,000.

On Sept. 25 the city council rejected all bids and authorized the city engineer to proceed with the work on a day labor basis. This is being done under Albert Givan, city engineer, George Calder, resident engineer, filtration division, and G. M. Mott, Jr., superintendent of construction.

As originally planned, the intake consisted of twin concrete pipes of 5-ft. inside diameter, 1,000 ft. long, to be placed with the invert 35 ft. below the present ground surface or about 15 ft. below the level of the water table. This depth proved a serious obstacle to the contractor and disagreement arose after delay and alleged excessive costs in unwatering the deep trench for the pipes and in driving the tunnel under compressed air, a method substituted for the open caisson work in the hope of improving progress and costs.

The plan of locating the conduits at so low a level has been abandoned; the bids referred to above were on a modified scheme which will use the original low intake and delivery terminals as already constructed but will span the distance between by a siphon, thus avoiding deep excavation. As now being constructed, the invert of the intake conduits will be only about 16 ft. below the present ground surface.

Flinn Elected as Director of Engineering Foundation

Election of Alfred D. Flinn as director of the Engineering Foundation has been announced by the chairman of the foundation. This is a new post, created by the governing board to meet the expanding needs of the foundation in its work of industrial research. This board is composed of representatives of the four founder societies of civil, mining, mechanical and electrical engineers.

Mr. Flinn will retire as chairman of the engineering division of the National Research Council, a position which he has held since October, 1921, but will continue as secretary of the United Engineering Society in order that the foundation may continue intimate relations with the Founder Societies. Mr. Flinn has been secretary of this Society and of the Foundation since January, 1918.

The Engineering Foundation Board adopted the report of the executive committee, which recommended a continuance of intimate relations with the National Research Council, including financial support.

The Engineer in Public Life

CHARLES T. MALE

This year another engineer joined the ranks of New York State's legislators. Charles T. Male, civil engineer of Niskayuna, N. Y., was named member of the New York Assembly from the First District, Schenectady County. Born March 8, 1889, he was graduated from Union College, Schenectady, in 1913 and received a master's degree in civil engineering the following year. He began his engineering work as secretary to Charles J. Bennett, state highway commissioner of Connecticut, in 1913, and up to the time the United States entered the war his professional activities included a period of teaching at Union College, service on the Panama Canal as sanitary inspector and topographic draftsman, and a period with the New York State Department of Health as sanitary inspector on special investigations in Long Island. From 1916 to 1917 he was engaged in building construction for the American Locomotive Co.

Entering the army in May, 1917, he served with rank of second lieutenant and first lieutenant, Engineers, and later as captain, Sanitary Corps. He spent seventeen months in France with the A. E. F. in charge of investigations of water supply for troops. On his return to the United States he resumed his connections with the American Locomotive Co., but left that organization in 1919 to become instructor in engineering mathematics at Union College, later rejoining the State Department of Health as assistant sanitary engineer. For a short time in 1921 he filled an unexpired term, by appointment, as town superintendent of highways at Niskayuna.

Assemblyman Male believes that the engineer, by virtue of his training for the utilization of natural resources, should help in the solution of the problems of the state. He has no sympathy with the belief that a professional man should keep out of politics.

Landis Award Committee Places 20,000 Workmen

The employment bureau of the citizens' committee to enforce the Landis Award in Chicago had placed, up to Sept. 7, more than 20,000 mechanics and laborers in the thirteen "outlaw" trades where the unions refused to accept the scale of wages and working conditions laid down by Judge Landis. Of this total 8,046 were carpenters; 2,947, laborers; 2,778, painters; 1,920, sheet metal workers; 1,247, plumbers, and 725 lathers Since the construction boom started the service bureau has averaged more than 100 placements per day.

Newark Retains Staniford in Bridge Case

The city of Newark, N. J., has retained C. W. Staniford, consulting engineer, of New York City, and former chief engineer of the Department of Docks of that city, to report on the proposed bridge of the Central Railroad of New Jersey across lower Newark Bay. Mr. Staniford has been instructed to make a survey of Port Newark and submit recommendations as to the practicability of re-routing traffic now on the Newark Bay bridge over the Newark branch bridge above Port Newark or through a new tunnel to be built under the bay.

Engineering Societies

Calendar

Annual Meetings

FEDERATED AMERICAN ENGINEERING SOCIETIES, Washington, D. C.; Annual meeting Washington, Jan. 11-12, 1923.

AMERICAN ROADBUILDERS ASSOCIATION, New York City; Annual Convention, Chicago, Jan. 15-18.

AMERICAN SOCIETY OF CIVIL ENGINEERS, New York City; Annual meeting, New York City, Jan. 17 and 18.

AMERICAN CONCRETE INSTITUTE, Detroit; Annual Convention, Cincinnati, Jan. 22-26.

ASSOCIATED GENERAL CONTRACTORS OF AMERICA, Washington, D. C.; Annual meeting Los Angeles, Jan. 30-Feb. 3.

Personal Notes

CHARLES F. WOOD, for the past four years designing engineer and assistant to the construction engineer on the Braden Copper Co.'s extension of plant in Chile to 10,000-ton daily capacity, has become associated with the Frederick Snare Corp. as construction engineer in charge of all port and terminal developments for the Ferrocarriles del Norte de Cuba at Puerto Tarafa, Cuba. Puerto Tarafa is at present the main sugar port of Cuba, exporting 700,000 tons of sugar annually.

LEWIS I. BIRDSALL, superintendent of filtration, water-works department, Minneapolis, Minn., has resigned to accept a position as water expert in the sales department of the General Chemical Co. at Chicago. Mr. Birdsall has been in the former position since the plant was started in January, 1913, and is well known in the water-works field, having written many articles on the operation of water-purification plants. He has been president of the Engineers' Club of Minneapolis and chairman of the Minnesota Section of the American Water-Works Association. ARTHUR F. MELLEN, assistant superintendent of filtration during the past four years, has succeeded Mr. Birdsall. Mr. Mellen is secretary of the Engineers' Club of Minneapolis,

and of the Minnesota Section of the American Water Works Association.

GERALD J. WAGNER, formerly director of public service of Grand Rapids, Mich., has been engaged by that city as consulting engineer in public utility matters.

WILLIAM E. WOOD, president of the W. E. Wood Co., Detroit, Mich., general contractors, has been nominated for president of the Associated General Contractors of America for the 1923 term.

VERNON R. COVELL has been appointed county engineer of Allegheny County, Pa., to succeed J. G. Chalfant who died recently. Mr. Covell has been deputy county engineer of Allegheny County for the past fifteen years.

L. P. O. EXLEY, office engineer for the Gulf, Mobile & Northern R.R. Co. and the Meridian & Memphis Ry. Co., has been promoted to assistant chief engineer, with headquarters at Mobile, Ala.

M. L. WORRELL, formerly of Meridian, Miss., has been appointed engineer and manager of the Vicksburg, Miss., water-works. He replaces J. A. STEELE, JR., former manager, who has resigned on account of ill health. Mr. Worrell is a former captain in the Construction Division of the Army. He was field engineer of several southern water plants from 1892 to 1907; superintendent of public works, Rome, Ga., 1908-10; and engineer and manager, water-works, Meridian, Miss., 1911-1917. He has been in the practice of public utilities engineering at Meridian and Lafayette, La., since his discharge from the Army.

SPOONER and MERRILL, consulting engineers of Grand Rapids, Mich., announce the opening of an office in the Harris Trust Building, Chicago, in charge of George Henry Knutson, formerly with the Harris Trust and Savings Bank. Mr. Knutson accepts the position as a resident partner.

CLARENCE R. MOORE, EDWARD W. SANFORD, EDWARD R. FOSTER, and HARRY W. FARRAND have been appointed by Director Caven, of the Philadelphia Department of Works, assistant engineers in the department.

PAUL STARRETT, formerly president of the George A. Fuller Co., and W. A. STARRETT, formerly a vice-president of the same company, have formed a partnership under the firm name of STARRETT BROS., INC., builders, with offices at 101 Park Ave., New York City. Both men are well known in the construction field. For thirteen years William A. Starrett was a member of the firm of Thompson, Starrett & Co., during five years of which time he had charge of all construction work, then becoming executive vice-president of the firm. He later became senior member of the firm of Starrett & Van Vleck, architects, New York City, still later becoming associated with the George A. Fuller Co. in an executive capacity.

EARL BRACKEN, formerly an office engineer with the Kittitas Reclamation District, Ellensburg, Wash., has become connected with Powell & Jacobs, consulting engineers of Hamilton, Mont., as office engineer.

EARL J. WHEELER, until recently in private engineering practice, is now associated with M. Tschrigi & Sons, of Cedar Rapids, Iowa, sanitary and municipal consulting engineers. Mr. Wheeler is in charge of paving and sewerage work.

STEWART BLACKMAN, formerly an assistant engineer in the Massachusetts Highway Commission, has become associated with the Kansas City Power & Light Co. as engineer and draftsman.

PAUL BAYLISS, a valuation engineer with the American Appraisal Co., has been appointed an assistant engineer with the Central Illinois Public Service Co. He is stationed at Galatia, Illinois.

J. MCLANE TATE, until recently a project engineer with the New Mexico State Highway Commission, is now connected with the Wilkie Woodard Co., of Los Angeles, Calif., civil and landscape engineers. Mr. Tate's position is that of assistant engineer.

F. M. TOWNSEND, until recently employed in the engineering department of the M., K. & T. R.R., is now with the Hudson River Connecting R.R. and stationed at Selkirk, Albany County, N. Y. His position is that of junior engineer.

HARRY D. ELLIOTT, formerly with S. S. Boggs, county engineer of Warsaw County, Ind., is now one of the testing engineers with the Illinois State Highway Commission.

C. K. REDFIELD is now a designing engineer for the Truscon Steel Co. and is stationed in the Detroit office. Mr. Redfield was formerly bridge engineer for the Oakland County Road Commission and located at Pontiac, Mich.

L. H. USILTON, formerly a superintendent of construction for the Turner Construction Co., New York City, is now connected in the same capacity with the Barney-Ahlers Co., New York City, industrial building contractors.

M. RADUS has severed his connection with the Submarine Boat Corp., with which concern he was employed as field engineer, to become associated with the New Jersey State Highway Department. His position is that of assistant civil engineer, and he is stationed at Washington, N. J.

H. M. NEIGHBOUR, until recently resident engineer on concrete paving, El Paso Co., Tex., has now become field man on concrete bridge work for the Maricopa (Ariz.) County Highway Commission. He is stationed at Phoenix.

L. L. SHIREY, formerly an assistant engineer with the C., C., C. & St. L. Railway Co., has been made a designing engineer with the same road. He is stationed in Cincinnati.

C. D. BOWSER, formerly employed by the Mount Vernon Bridge Co., of Mount Vernon, Ohio, has been elected an instructor in structural engineering at the University of Michigan.

J. E. BUTLER, building inspector of Richmond, Va., has tendered his resignation. It became effective Oct. 1. However, reconsideration of his decision to resign has been sought by builders, contractors, and other interested business men in Richmond through the circulation of a petition. As yet no successor has been named.

OBITUARY

HENRY P. BORDEN, a former member of the Board of Engineers of the Quebec Bridge, at one time consulting engineer to the Department of Railways and Canals of the Canadian government, and more recently in private consulting practice in Ottawa, died in that city Oct. 19. Mr. Borden was born in Port la Tour, N. S., and was graduated from McGill University, Montreal. He began his professional career as an assistant engineer in the bridge department of the Canadian Pacific Ry. at Montreal. He then became assistant chief engineer in the structural department of the Montreal works of the American Locomotive Co. Later he was made structural engineer for the Canadian Pacific. In 1908 he became assistant engineer, Board of Engineers of the Quebec Bridge, being appointed a member of the board early in 1916 upon the death of C. C. Schneider, a position which he held until the work was finished. From 1919 until 1921 he was engaged by the dominion government in a consulting capacity. He was a member of the Engineering Institute of Canada and of the American Society of Civil Engineers.

CHARLES P. LOVELAND, a civil engineer of Montreal and a native of Bangor, Me., died in Montreal Oct. 19, aged 51 years. Mr. Loveland had gone to Canada in 1907 in connection with municipal water-works contracts. Later he became identified with the Leahy Construction Co., and still later with the J. W. Harris Manufacturing Co.

R. C. P. COGGESHALL, for the past 50 years connected with the water-works of New Bedford, Mass., and for more than 25 years of that time its superintendent, died in that city Oct. 20 after an illness of many months. Mr. Coggeshall was widely known in the water-works field having been one of the first secretaries, presidents and editors of the New England Water Works Association. He was also active in the American Water Works Association. An extended biography will appear in a later issue.

JOHN N. COLE, state commissioner of public works of Massachusetts, died Oct. 18 in Boston. Mr. Cole had been prominent in public affairs in Massachusetts for twenty years or more. He entered newspaper work when a young man, becoming publisher of the paper first employing him. He successively occupied the positions of representative from Andover to the state legislature, speaker of the Massachusetts House, chairman of the Commission on Waterways and Public Lands, and Commissioner of Public Works. Into the last commission was merged the Waterways and the Highways Commission. Mr. Cole had always been a hard worker in any public position he occupied and during the last two years had made a particular fight to secure increases in motor-vehicle fees in Massachusetts in order to have more money with which to build roads.

From the Manufacturer's Point of View

Water-works Men Give Views on Buying Pipe in Winter

Discussion Starts on Proposal of Manufacturers To Spread Purchases Over Entire Year

AT *Engineering News-Record's* request a number of water-works engineers and water department officials have expressed their opinions regarding the desirability of buying cast-iron pipe during winter and increasing the amount of construction in cold weather, as suggested by the manufacturers in last week's issue. The discussion follows:

FRANK A. BARBOUR
Barbour & Dixon, Civil and Sanitary Engineers, Boston

In reference to spreading the purchase of cast-iron pipe throughout the year, there can be no question as to the desirability of such action from the standpoint of economy in manufacture.

Just how far the reduction in cost of the pipe would, in New England, be offset by increased cost of handling and laying is a question. In cross-country lines, where the work is large enough to justify modern trenching equipment, your statement that the cost of excavation will not be much increased may be true, but on the average job in New England winter work does not pay. Snows interfere and the efficiency of labor falls with low temperatures.

Of this fact we had a clear case last year in pipe-line work in western Massachusetts extending from Oct. 15 to Dec. 15. At the latter date the ground was frozen to a depth of 1 ft. and during the last month the men were more busy fighting the cold than in doing effective work. After Nov. 15 on the average pipe-line job in New England field costs markedly increase and, in my judgment, any experienced contractor —aside from the greater difficulty of handling frozen ground—will allow for decreased efficiency of labor under winter conditions.

In many cases it is entirely feasible to string the pipe along the line and lay the following spring, but this is not generally true in streets, particularly in the case of large pipe. Whether it is economically advisable to purchase in the winter months, place in storage yards and rehandle in the spring depends, of course, on the differential between prices at the demand peaks and under winter conditions. In any case storage in the air does not improve pipe coatings—particularly the coatings of the quality now frequently furnished.

In general, if the problem is viewed on the simple basis of final cost, there is much to be said for the present New England practice of taking delivery of the pipe only during the season of favorable weather. If final cost is made only a relative factor and the value to local labor of spreading the working period over a longer time is introduced, it is not unlikely that more winter work can be wisely undertaken in New England than has been the case in the past. It will, in my judgment, involve greater expenditure by the particular department adopting such practice, but it may re-act to the general good.

CARLETON E. DAVIS
Chief, Bureau of Water, Philadelphia

The arguments in favor of spreading purchases of pipe through the entire year are sound. Pipe users and pipe makers should co-operate to make the practice effective.

As an incentive, the foundries, following the practice which coal-mining companies apply to summer purchases, might offer a discount for winter orders. When pipe prices are stabilized such discounts might be tangible and sufficiently evident to form a real inducement to the purchasers.

There will always be an element of human nature working towards seasonal, rather than steady, buying. Once a large project, for the authorization of which considerable effort has been made, is finally financed, a strong demand for its immediate consummation arises, and quick results are required. Stock purchases of pipe for routine extensions are not subject to the same urge for action. Such buying could wisely be concentrated in the winter.

The buyer and the seller are both interested in uniformity of output and towards that end I suggest consideration of a discount for winter work.

Discussion will continue next week.

Highway Industries Exhibitors to Discuss Road Show Plans

The first meeting of directors of the Highway Industries Exhibitors Association will be held in Chicago, Oct. 27, to complete details of incorporating the association and to discuss the allotment of space to exhibitors at the Good Roads Show to be held at the Coliseum, Chicago, beginning Jan. 15.

The association has received from the Secretary of the State of Illinois a charter of incorporation. At the forthcoming directors' meeting by-laws will be adopted, officers elected, and an executive committee appointed.

Metal Lath Varieties to Be Reduced

Following the practice of a number of other producers of structural materials, the manufacturers of metal lath are co-operating with the Department of Commerce in an effort to cut the excess varieties out of a long list of products. A preliminary meeting was held in Washington Oct. 2 and a formal meeting has been arranged for Dec. 12, at which representatives of the metal lath industry, architects, plasterers, lathers, contractors, and dealers will be invited to a joint conference. W. B. Turner, of the General Fireproofing Co., Youngstown, Ohio, is chairman of the Industry Committee on this matter, and Wharton Clay, commissioner of the Associated Metal Lath Manufacturers, is secretary.

Federation to Report on 12-Hr. Shift in Industry

Will Answer Vital Questions Regarding Work Conditions and Their Effect on Production

Some weeks will expire before the Federated American Engineering Society report on the twelve-hour shift in American industry is available. The manuscript, however, is in the printer's hands. The report attempts to answer the following questions:

What is the extent of continuous work in American industry; what the the alternatives to the twelve-hour shift; are there technical difficulties in changing from two-shift operation; how does the change from two to three-shift operation affect the number of shift workers; what are the factors to be considered in changing from two- to three-shift operation; what is the effect of eight-hour as compared with twelve-hour shift operation, on the quantity and quality of production, absenteeism, labor turnover and industrial accidents; how do wage rates on eight-hour shift operation compare with wage rates on twelve-hour shift operations; what is the general opinion of managers of three-shift plants regarding three-shift as compared with two-shift operation; do employees make good use of the increased hours of leisure; and to what extent have plants reverted to two-shift operations?

Will Deliver Construction Plant Catalogs in Russia

An offer to deliver catalogs of American manufacturers of construction plant and materials to the leading engineering society in Moscow, Russia, has been received by *Engineering News-Record* from Marcus S. Hill, who is planning to sail for Russia early in November, as a representative of three firms selling surplus army clothing, meat packers' supplies, and plows.

"After an absence of three years," Mr. Hill writes, "I will return to Russia on business and will be happy to take with me any literature pertaining to technical or engineering subjects which readers of your journal feel inclined to contribute. Catalogs (in duplicate only) covering equipment used in excavation, building construction, and every phase of general construction will, I know, be keenly appreciated, as well as catalogs describing plant employed on municipal work, power plants and irrigation.

"Business," Mr. Hill adds, "may or may not come from the sending of these catalogs—that is not the main object just now—but I am confident that the men reading the literature for which I am asking will never forget the kindly feeling shown by the firms which respond to this request and will remember the senders when opportunity offers in the form of possible business. All the literature received will be handed to engineering societies in Moscow."

Manufacturers who wish to avail themselves of Mr. Hill's offer may send their catalogs and other literature (in duplicate only) to Marcus S. Hill, care of the Editor, *Engineering News-Record*, 10th Ave. at 36th St., New York, N. Y.

Business Notes

J. S. MUNDY HOISTING ENGINE CO., Newark, N. J., has under way an expansion of its plant in the form of a 40 x 96-ft. corrugated steel building for the storage of boilers and stock parts for its hoisting engines. It will be equipped with a monorail and 5-ton electric hoist. The new structure will relieve the congestion in its main shop due to the recent installation of new machine-tool equipment, including six new boring mills, several milling machines, new cylinder planers, and drill presses. Since Jan. 1 production at the Mundy plant has increased 100 per cent and plans are now under way to double existing manufacturing facilities by constructing, this spring, a new building prolonging the existing main shop and installing additional equipment.

F. L. PADDOCK, former manager of the Chicago office of the Hydraulic Steel Co., has become secretary-treasurer of the Racer, Gale, Paddock Co., Lantana, Fla., a real estate development organization.

Equipment and Materials

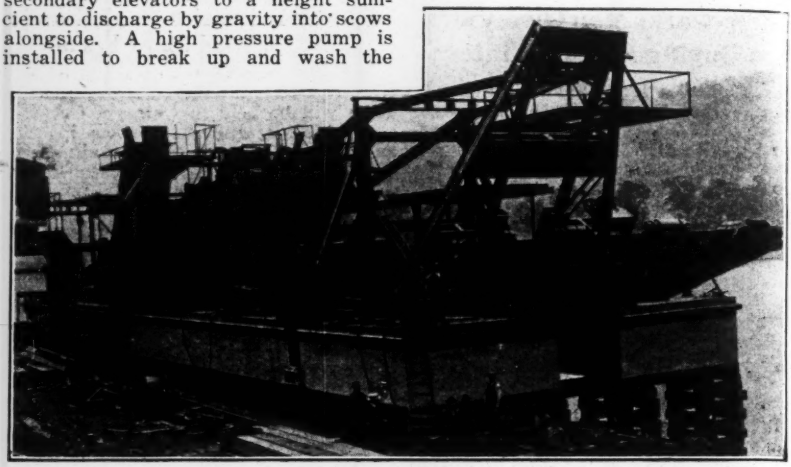
Big Sand Dredge Has Diesel-Electric Power Equipment

Special design features, chief among which is the use of Diesel-electric power equipment for driving an endless chain of heavy excavating buckets, each of 8 cu.ft. capacity, have been incorporated in the large floating elevator dredge for reclaiming river sand and gravel which the Bucyrus Co., South Milwaukee, Wis., constructed recently for the Iron City Sand Co., of Pittsburgh. The dredge, fully equipped, weighs 900 tons and its manufacturers give its capacity as 150,000 cu.yd. per month. It will dig 50 ft. below the water surface.

Material, as excavated, is delivered to barges alongside and by means of screens is separated into sand and three grades of gravel. Any or all of the various sizes of gravel may be saved or rejected as desired. The oversize stones—everything in excess of 2¾ in.—are rejected by the screen and returned to the river. Stones over 8 in. in diameter are rejected by a set of grizzley bars before reaching the screen.

The digging end of the dredge consists of an endless chain of close-connected 8-cu.ft. buckets mounted on a structural steel digging ladder 95 ft. long, suspended concentrically with the upper tumbler and inclined at an angle of 45 deg. for a maximum digging depth. Each bucket weighs approximately 1,500 lb. and consists of a nickel-chrome steel casting, forming a link and bowl, with manganese steel lip for the cutting edge. The complete weight of the ladder with its chain of buckets and tumblers is approximately 225,000 lb.

Excavated material is delivered through a hopper into a revolving screen 7 ft. in diameter by 32 ft. long. The sand screen is about 8 ft. 6 in. in diameter by 16 ft. long and surrounds the revolving screen at its upper end. The sand and various grades of gravel are conducted by chutes to sumps in either side of the hull immediately abreast of the revolving screen. From these sumps it will be carried by secondary elevators to a height sufficient to discharge by gravity into scows alongside. A high pressure pump is installed to break up and wash the material which is delivered to the screen.



Power for operating the dredge is supplied by a 300-hp. Diesel type, four-cylinder, two-cycle, solid injection oil engine manufactured by the Worthington Pump & Machinery Corp. This engine operates at a speed of 277 r.p.m. and is direct-connected to a 270-kva. Westinghouse, 3-phase, 60-cycle, 440-volt generator.

The bucket line is driven from a 125-hp. motor which is also used for raising the spuds and hoisting the ladder. The revolving screen is driven through a series of gear reductions and a friction drive roller from a 50-hp. motor. The secondary elevators are driven through suitable gear reductions from 15-hp. motors mounted overhead near the elevator tumblers.

The dredge is held to its work by four, steel-armored wood spuds which are about 65 ft. long and mounted in casings at either side of the dredge near the bow and stern. The principal movements of the dredge will be controlled by a single operator located in an overhead pilot house or lever room, so that he can at all times command a good view of the bucket line.

The hull is of steel construction throughout, having a length of 160 ft., a width of 40 ft. and a depth of 7 ft.

The Diesel electric power equipment was chosen primarily because of the trouble encountered in various rivers with impure boiler feed water. The plant, the Bucyrus Co. claims, will be more economical in operation than a steam dredge.

Shovel Company Seeks Records of Operating Costs

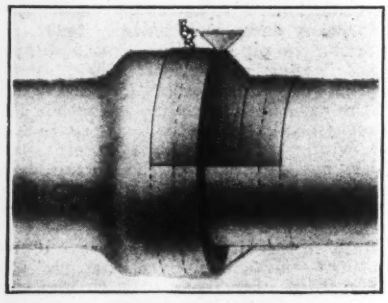
The Erie Steam Shovel Co., Erie, Pa., announces a prize competition to secure data on the output and cost of operation of its revolving steam shovels. The contest is now open and will continue until Dec. 31. Conditions are outlined as follows:

"Records may be sent in by steam-shovel owners, managers or any employee in direct contact with steam shovel work. In every case, however, the record must be accompanied by a written statement from the owner of the machine to the effect that the figures submitted are correct to the best of his knowledge. The record should include approximate number of days the machine has worked, yardage moved, class of materials, and all upkeep costs exclusive of cable, dipper teeth and grate bars."

Further information regarding the contest may be secured from the Erie Steam Shovel Co., Erie, Pa. The judges of the contest will be Arthur S. Bent of Bent Bros., contractors, Los Angeles; Halbert P. Gillette, editor *Engineering and Contracting*, Chicago; and A. C. Vicary, vice-president, Erie Steam Shovel Co.

Waxed Paper Gasket for Poured Sewer Pipe Joints

For pouring bituminous or grout joints in vitrified tile sewer pipe the G-K Sales Agency, Macungie, Pa., has developed a special gasket of thin waxed paper, in two sections, shaped to conform to the bell and spigot of the pipe. As shown in the accompanying illustration, the gasket is fastened on



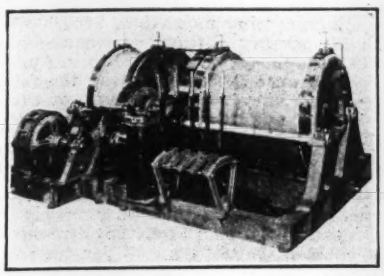
the pipe with cord. It has sufficient strength to sustain the weight of the compound or grout and is not affected by the heat of the jointing material.

The gasket was designed in an effort to secure a more practical runner than the asbestos jointer ordinarily used. With the latter, backfilling of the trench must be delayed until the joint compound has set, entailing loss of time and labor in removing the runner. With

the waxed paper gasket the pipe layer or inspector can pass his hand around the joint and determine, by the radiation of heat, whether the whole joint is filled. The gasket, it is claimed, is so inexpensive that contractors find it economical to leave it on the joint and backfill as soon as pouring is completed.

American Hoisting Engines for Service in Japan

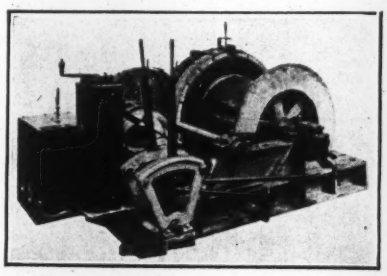
For use on construction projects in Japan the J. S. Mundy Hoisting Engine Co., Newark, N. J., has recently shipped six hoists embodying special features of design. Two of the units are intended for cableway service and hydro-electric developments for which the firm of Thebo, Starr & Anderton, San Francisco, are consulting engineers. Illustrated is a 75-hp., two-speed unit with a



TWO-SPEED, 75-HP. CABLEWAY HOIST

capacity of 50,000 lb. The drum is 53 in. in diameter and 42 in. long, and will serve a cableway span of 1,250 ft. Vertical hoisting speeds of 25 and 100 ft. per minute and horizontal traveling speeds of 500 ft. per minute are provided for. This hoist is equipped with double brakes, allowing the handling of heavy loads on long lifts.

The other hoist is a single-speed, 140-hp. unit, capable of raising loads of 5,000 lb. at 200 ft. per minute. The



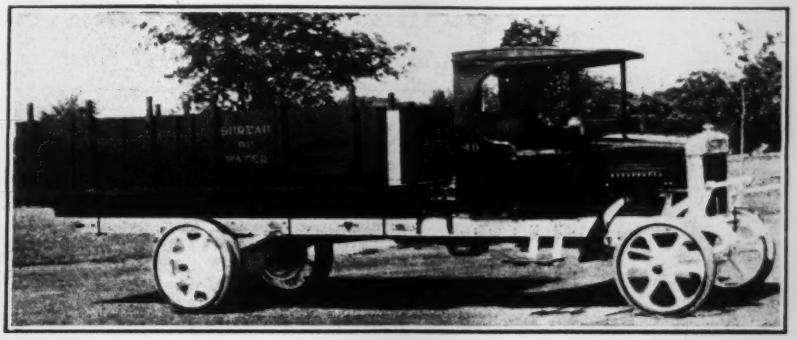
80-HP. HOIST FOR OVERHEAD TRAMWAY

maximum horizontal traveling speed is 1,000 ft. per minute.

The four hoists for overhead tramway service, previously referred to, are of 67, 80, 100, and 300 hp. respectively. A feature of their design is the use of cast steel drums to provide extra strength and solenoid brakes for safety.

New Model of Heavy Duty Truck

A new model of its 3½ ton motor truck for general heavy duty is announced by the Atterbury Motor Car Co., Buffalo, N. Y. The chassis weight is 7,500 lb., body weight allowance 2,500 lb., and among its features are the latest type of Continental motors (four cylinders, 32.4 hp.), amidship transmission, left-hand drive and com-



plete electric lighting equipment. The truck has four speeds forward and one reverse. The frame is of hydraulic pressed steel, bolted throughout, no rivets being used.

The standard wheelbase is 14 ft. 6 in., although a special short wheelbase of 12 ft. 6 in. and a special long wheelbase of 16 ft. 6 in. are provided. The short-wheelbase truck is designed especially for contractors' use with a 10-ft. dump body. For this truck claims of operating flexibility are made due to its short turning radius. The photograph shows a 16½-ft. wheelbase model for the Bureau of Water, Buffalo, N. Y.

Publications from the Construction Industry

Asphalt Pavement—BARBER ASPHALT Co., Philadelphia, in an illustrated booklet entitled "The Last Analysis," presents service records of pavements in which Trinidad Lake asphalt has been employed. The first sheet asphalt pavements constructed in this country about 48 years ago, it is stated, were built for the most part of Trinidad asphalt, in Newark, N. J., Washington, D. C., and New York City. Yardages of asphalt pavement in a number of cities and their ages are listed.

Compressed Air Tools—INGERSOLL-RAND Co., New York, has just issued a 32-p. booklet entitled "Trench, Tunnel and Pipe Work by Compressed Air" in which many uses of air tools by contractors and public utilities are described and illustrated. Many of these uses have only been developed recently in connection with the portable wagon-mounted air compressors. Among the subjects covered are pneumatic clay diggers for both trench and tunnel work, paving breakers for cutting pavement, Jackhamer rock drills in trench work, pneumatic calking of lead wool and cast lead, pneumatic backfill ramming and service pipe installation. In each case the use of the air tool is compared to the hand method to show the actual saving.

Anti-Slip Tile—AMERICAN ABRASIVE METALS' Co., New York, sales representatives for the Carborundum Co., Niagara Falls, N. Y., features anti-slip tile for stair treads, elevator landings, ramps, and general floor surfaces in a 22-p. illustrated booklet. The tile are made of one of the modern artificial abrasives, a product of the electric furnace, crushed and mixed with clays and other ceramic materials and finally molded into various sizes and shapes. The tile are then vitrified in high temperature kilns. The tile cannot wear smooth and have a high resistance to wear, according to the claims of their manufacturer. The booklet illustrates the use of the anti-slip tile on stairways, floors, ramps and swimming pools. A specification guide for the placing of the tile also is included.

Treated Ties and Timber—CENTURY WOOD PRESERVING Co., Pittsburgh, has issued Bulletin 24 dealing with treated ties and timbers for industrial plants. It comprises 24 pp., illustrated, covering the destructive influence of moisture on timber and methods of preventing it. Three processes used in timber treatment—surface application of preservative, open-tank treatment, and treatment in closed cylinders under pressure—are described. Suggestions also are offered on best methods of seasoning timber before treatment. Several methods of handling ties and timbers rapidly and at low cost are indicated and the concluding portions of the text deal with posts, poles, piling, and wood-block floors and pavements. Tables are given showing size and contents of cross-ties, preservative required and cubical contents of round poles and piling.

Auto Truck Snow Plow—BAKER MANUFACTURING Co., Springfield, Ill., describes in a 12-p. illustrated booklet its detachable snow plow for motor trucks. It is made in two sizes, an 8-ft. and a 10-ft. blade, the larger size generally being used on trucks of over 3½ tons capacity. The device is attached to the truck through clamps gripping the axle just between the spring shackle bolts. The blade proper, 6 in. high, is hinged to a mold-board 16 in. high and is held in position by compression springs on the back of the blade. This hinged construction is a special feature of the device for it allows the blade to be tripped in the event of its striking an obstruction. In this event the 6-in. height of the blade swings back, allowing a minimum amount of snow to be passed over without removal. Furthermore, the fact that the blade is divided into two sections longitudinally still further reduces the area through which snow may be lost when the blade is tripped. A lifting device enables the blade to be raised or lowered and it is also possible to adjust the blade to any angle desired The company also manufactures a V-shape, two-way plow for trucks.

Business Side of Construction

Facts and Events that Affect Cost and Volume

Business Inflation and the Present Outlook

Review of a Monthly Survey Made by the National City Bank of New York

In its monthly survey of business conditions, the National City Bank of New York describes the conditions that bring about business inflation, and surveys the present situation from that angle. After pointing out the tendency of business to run in cycles, with greater confidence and activity in some years than in others, the discussion points out that development on the up trend reaches a point beyond which it is not called to pass by the demands of legitimate, wholesome expansion.

"When confidence has been completely regained and belief in a lengthy period of prosperity is established, the sanguine, speculative spirit develops. It is stimulated by the deficit in many kinds of goods and constructional work that accumulated during the depression. Consumption having been below normal for a time, the demand now rises above normal and stimulates the industries to the limit of their capacity. It does not stop there but tries to drive them beyond their capacity. Various phenomena develop now; dealers double their orders expecting them to be scaled down, or duplicate them with different producers. Manufacturers build and equip new factories to enable them to take care of the business that seems to be in sight and raise wages to attract labor from competitors or from other industries; advancing costs make it necessary to use more bank credit.

"By this time the situation is becoming abnormal. The demand for nearly everything is above the supply and above the normal or average demand, to which in the long run prices are surely adjusted. It is stimulated by speculative anticipation and by competitive buying, supported by cradit.

"The banks respond to the appeal of their customers who say that they want credit for legitimate needs in production and trade, but if production already has reached the capacity of the industry, additional credit simply finances competition for labor and material and drives wages and prices higher and higher. This is inflation: The use of credit as purchasing power in excess of productive capacity."

The discussion points out that although prices have recently shown a slight recovery after the considerable fall from war-time levels, the gain cannot be called secondary inflation; but looks like the recovery that always comes when old stocks are exhausted and industry gets fairly under way again. "Although the war time was anything but a period of depression, it continues, some of the effects were similar to those resulting from a period of depression. Industry in some lines fell behind the normal growth of the country, creating a deficit of supply or accumulation of demand. This is true in house building, in the construction of railway equipment. and in some other lines, and a revival has occurred in those lines. It is due to imperative needs rather than to a belief that the bottom has been finally reached in construction costs, although the feeling doubtless prevails that prices are not likely to go lower until the existing shortage is in large part made up. The advance in wages is due in part to the revival of industry, but in large part to the immigration act."

It is pointed out also that abnormal conditions in some of the industries are influencing prices, as for example, the effect of the coal strike upon iron and steel, which in turn has affected all industrial costs. It is contended that buyers are not contributing to inflation but are buying cautiously for immediate needs only. The increase in the demand for credit has been chiefly to carry stocks and other securities; and the rise in these indicates that capital is accumulating and that there is faith in the country's stability and progress. Although financial conditions are favorable for the encouragement of a period of inflation, it is believed that those who are counting upon one do so in the belief that the American people with their optimistic mentality cannot let pass an opportunity of the sort. To offset this, however, it is believed that the lessons of the last few years have been too deeply engraven upon the minds of American business men and that they will be reluctant to borrow and spend recklessly in expectation of an imminent boom.

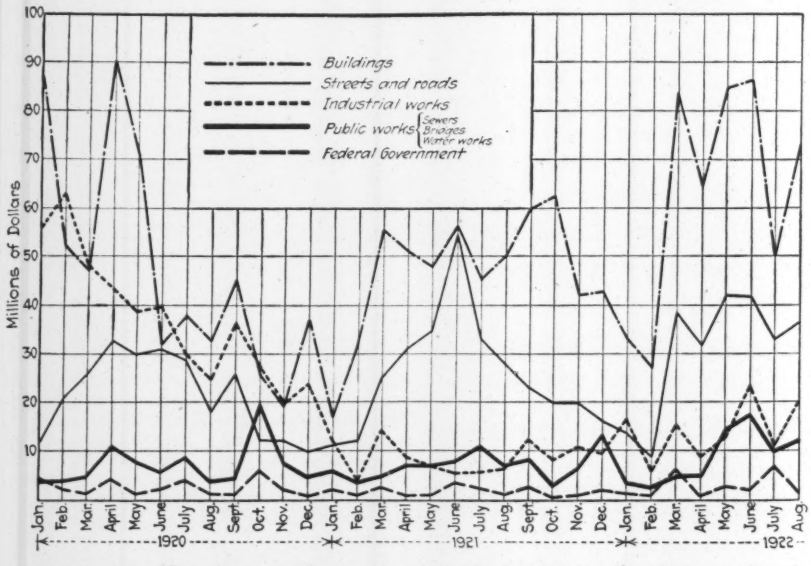
The Construction Industry Since January 1920

The accompanying chart sums up, graphically, the volume of construction contracts let during the period between January, 1920, and the present. The five principal classes of construction reported by *Engineering News-Record* have been segregated to show the effect of changing business conditions in each of the fields.

Most noticeable at first glance is the slump after the summer of 1920 and the present upward trend. Picking out the individual curves we find that buildings—mainly commercial and public buildings costing more than $150,000—fell off sharply during the summer of 1920, dropping from $90,000,000 in April to less than $20,000,000 during the following January. A large share of this drop was due to the inflated cost of building which made new construction almost prohibitive. With the falling off in costs and an increasingly urgent demand as a result of the long cessation from building during the war, this class of construction held fairly uniform during 1921 at better than 50 per cent of the 1920 peak. A fair volume of contracts was let during the last winter and this season has seen a consistently high voume of contracts awarded.

The volume of industrial construction reflects very accurately the trend of business in general. From the peak of 1920 it declines with exceptional uniformity to the low point of 1921. Today it is on a slight upgrade—very slight, indeed—but none the less accurately portraying a corresponding situation in general business.

Streets and roads show the seasonal troughs and crests but reflect the impetus that has been given to highway building by the Federal-Aid legislation. Money was not so plentiful in 1920 and the volume of contracts awarded was somewhat restricted in consequence, but in 1921 the highway construction program fairly attained its stride.



Construction Equipment Exports

For the month of July, 1922, the Department of Commerce has issued figures on exports of construction equipment from the United States. During that month 152 concrete mixers, valued at $93,702, were shipped. Of that number, 104, valued at $61,435, went to Japan; 7, valued at $8,475, went to Quebec and Ontario, Canada; 7 were sent to British India and 4 to Mexico.

Federal-Aid Roads Have Record Year

More Than 10,000 Miles of Highways Completed During Year Ending June 30—Labor Costs Higher

More than 10,000 miles of Federal-aid highways were completed during the fiscal year ending June 30, according to a compilation by the Bureau of Public Roads. The Bureau also reports that the present calendar year has exceeded all previous records for road construction, incomplete data leading the Bureau to estimate that during 1922 the sum of $742,000,000 will have been spent on Federal-aid highways, State roads and projects constructed by other agencies.

On July 1, 1921, the Bureau's figures showed the total mileage of completed Federal-aid highways at 7,500, with an additional 18,000 miles in various stages of construction. On June 30 last, the completed Federal-aid mileage had more than doubled, the total being 17,700 miles, with 14,500 miles under construction, estimated by the Bureau to be 56 per cent completed, on the average.

Texas led the states in total mileage of Federal-aid highways completed in the fiscal year ended June 30, with 933 miles. Arkansas, Georgia, Iowa, Minnesota and North Carolina each reported more than 500 miles of Federal-aid roads completed within the year, the Bureau's announcement states, while Montana and Wisconsin each completed more than 400 miles.

The statement shows that since 1916 more than 30 miles of bridges have been built on Federal-aid projects. One of these, from Mandan to Bismarck, N. D., is 3½ miles long and cost $1,428,000, of which the Federal government contributed half.

Wage schedules, applying on thirty-nine different kinds of labor used in Federal-aid road work in August, show slight advances over those in effect during June. Common labor, for instance, in road paving operations, advanced 1c. per hr. in the East and West South-Central Sections as well as in the West North-Central Division; the same grade of labor rose 3c. in the East North-Central, 4c. in the Mountain Division and 5c. per hr. in both the New England and Middle Atlantic States. The South Atlantic Group quoted 39c. in August as against 20c. per hr. during June. In the Pacific Division, however, the rate remained unchanged, at 50c. per hr.

Fewer Bad-Order Cars Than at This Time Last Year

Freight loadings for the week ending Oct. 7 totaled 968,169 cars, a decrease of 20,212 from the week preceding but an increase of 68,488 over the corresponding period in 1921. A considerable part of the reduction in total cars loaded, however, is undoubtedly due to the heavier loading of each individual car. This has resulted in a decrease in the number of cars required for the same tonnage, thereby increasing the available supply. The American Railway Association further reports shortages of 71,063 box, 40,499 coal and 141,252 general freight cars for the week ended Oct. 7.

Bad-order cars, however, are at present about 20 per cent under the number on hand at this time last year.

The railways of the country reported 44,703 serviceable locomotives on hand Oct. 1, as against 19,727 in need of repairs. This represents an increase of 538 over the number serviceable on Sept. 15, due to the installation of new locomotives as well as the greater number being repaired and turned out by the shops.

Propose that Congress End Issue of Tax-Free Securities

Proposals to end the issuance of non-taxable securities will be urged upon Congress at its short session, according to reports current in Washington. The question of tax-free bonds is said to be tied up closely not only with the tax problem but also with the general industrial prosperity.

Diversion of capital from private industry to the shelter of tax-free bonds of cities and other sub-divisions of states is declared to have reached such a point that public debts are being run up beyond reasonable needs while business in general is forced to pay unreasonable interest charges to raise the capital for much-needed development.

Plans now under discussion contemplate a resolution proposing a constitutional amendment to outlaw tax-exempt securities. Support is expected from President Harding, Secretary Mellon and other treasury officials. In other quarters it is held that no constitutional amendment is necessary or desirable, and that if the federal government will desist from issuing tax-exempt bonds the way will be open for the states

AUGUST FEDERAL AID LABOR REPORT—AVERAGE HOURLY PAY BY GEOGRAPHIC DIVISIONS

Kind of Labor	New England			Middle Atlantic			East North Central			West North Central			South Atlantic			East South Central			West South Central			Mountain			Pacific		
	Grade	Pave	Structural	Grade	Pave	Structural	Grade	Pave	Structural	Grade	Pave	Structural	Grade	Pave	Structural	Grade	Pave	Structural	Grade	Pave	Structural	Grade	Pave	Structural	Grade	Pave	Structural
Foremen																											
Miscellaneous			1.00		.55						.50														.56	.55	
Superintendents	1.10	1.10	.93	1.12	1.18	1.05	.76	.95	.98	.88	1.05	.88	.74	.83	1.00	.86	.56	.55	.92	.88	1.18	1.00	1.02	.98	1.14	1.15	1.00
Foremen	.67	.70	.77	.68	.67	.67	.70	.67	.67	.65	.70	.62	.48	.51	.57	.58	.56	.55	.50	.59	.64	.71	.70	.75	.81	.85	.81
Subforemen	.66	.55	.68	.56	.58	.55	.47	.54	.56	.48	.54	.57	.37	.41	.42	.57	.45	.42	.43	.47	.48	.59	.63	.59	.67	.67	.73
Operators																											
Miscellaneous					.50		.50	.54		.61	.43	.55	1.00	.62	.40		.41	.31		.43	.50	.63	.67	.61	.62	.61	.62
Auto drivers			.45	.53	.44	.33		.48		.50	.35	.43	.28	.25			.38			.52			.40	.50	.56	.60	.56
Truck drivers	.52	.51	.46	.45	.44	.43	.36	.41	.36	.38	.38	.38	.27	.35	.35	.30	.35	.32		.34	.27	.55	.53	.45	.65	.66	.63
Roller engineers	.66	.64	.50	.55	.62		.55	.48		.41	.54	.70	.45	.49		.51	.44		1.00			.54	.65		.74	.75	
Machine drillers	.58	.60		.51	.48						.40	.70	.35	.39		.60	.33		.50	.35		.54	.75		.62	.62	
Mixer operators		.70			.66	.51		.55	.59	.37	.60	.38	.60	.53	.41	.43	.47	.32		.59	.32		.63	.62		.97	.73
Steam shovel operators	1.01	.94		.90	.96	.65	.88			.72	.50		.81	.72		.76	.63		1.12	.65		.84	.60	.78		1.10	
Tractor operators	.47	.43		.49	.47		.55	.48		.58	.56		.32	.39		.36	.37	.45	.60	.43			.67	.75	.76	.71	.75
Jackhammers	.50	.50		.49	.54					.53	.40			.32		.27	.29	.45				.57			.67	.59	
Crane operators	1.16	.92			.75	.75		.72	.73	.62	.66			.77			.49	.60		.66	.58	.62	.64			1.10	
Enginemen	.64	.57	.47	.51	.50	.55	.55	.44		.50	.49	.49	.44	.30	.48	.46	.40	.38		.42	.53	.60	.66		.69	.75	
Skilled labor																											
Miscellaneous		.60	.60	.56	.45	.50	.68	.40		.54	.50	.44	1.10	.32	.34	.45		.36			.75	.50	.53	.50	.60	.64	.62
Blacksmiths	.51	.55	.59	.50	.55	.57	.45	.68	.40	.56	.66		.33	.50	.50	.43		.50	.44	.41	.40	.62	.55	.58	.66	.71	.72
Bridgemen			.85			.81				.60		.49			.82			.51			.41		.50	.42			.62
Carpenters	.57	.60	.68	.55	.53	.53		.60	.52		.60	.64	.60	.48	.45	.69		.48		.75	.51	.65	.60	.67	.80	.75	.77
Bridge carpenters			.82		.67	.67			.48		.50	.51		.40	.48	.75		.50			.55		.49	.67	.70		.63
Drillers	.56	.50		.48	.52		.50			.51	.48		.35	.26		.26	.35			.20		.48			.53		
Firemen	.67	.60		.48	.47	.40	.47	.38	.40	.45	.37	.45	.31	.38	.28	.40	.35	.26		.27	.27	.50	.52		.74	.66	
Finishers					.53	.45		.46			.46	.70	.45	.51			.30	.30		.45	.38		.53	.70		.54	
Concrete finishers		.53	.50		.50	.50		.51	.59		.53		.40	.33	.32	.35	.46	.31		.43	.34		.55	.53			.68
Masons			.82	.42										1.00	.54			.61			.22			.71			.52
Mechanics	.52	.62			.56	.51		.71	.60	.34	.47		.75	.51	.60	.71	.52	.52		.44		.83		.75	.65	.40	
Powdermen	.45			.50	.53					.53	.41		.43	.30		.60	.26		.30	.35		.61			.62	.61	
Commissary labor																											
Miscellaneous					.50					.50				.30			.35					.56	.55	.60	.59	.59	.50
Cooks	.53	.45		.50	.50		.54	.46	.60	.43	.49	.33	.30	.36		.21	.22	.22	.24	.25	.43	.47	.43	.34	.55	.53	.54
Assistant cooks	.37				.40		.45	.45		.28	.38	.30	.20	.27		.14	.14	.12		.17	.35	.37	.31	.37		.30	
Cooks' help	.30	.30				.30	.38			.28	.27	.32		.20		.15	.14	.15	.20	.12	.20	.39		.26	.36		
Flunkeys	.10			.35	.30					.29	.27			.17		.15	.15	.13	.19	.14	.17	.34	.30	.30	.31	.35	
Waiters													.35			.14	.12	.12	.10	.10	.10				.49	.40	
Common labor																											
Miscellaneous																									.43	.40	
Common labor	.40	.43	.42	.36	.38	.38	.34	.33	.35	.31	.33	.32	.31	.39	.50	.22	.21	.23	.25	.25	.25	.40	.39	.37	.50	.50	.51
Teamsters	.39	.40	.34	.43	.48	.46	.34	.38	.32	.28	.29	.30	.50	.57		.24	.17	.23	.23	.25	.24	.40	.39		.50	.44	
Teams																											
Teams	.68	.72	.60	.68	.70	.67	.31	.40	.47	.25	.27	.26	.20	.21	.19	.42	.46	.46	.37	.37	.35	.36	.31	.62	.38	.36	
Team incl. teamsters	.72	.76	.77	.69	.70	.68	.63	.63	.63	.59	.64	.59	.20	.24		.47	.48	.49	.48	.48	.46	.73	.47	.61	.62	.80	
3 Horse teams	1.02	.60										.62															

Note—Rates in dollars and fractions of dollars.

and municipalities to follow suit. It it held that one reason for the spread of the tax-free bond is the competition of the federal securities of that description.

Final Cement Figures Slightly Higher Than Estimated Total

Final figures on the output of portland cement during 1921, compiled by the United States Geological Survey from reports of all producers, show that production was a little less than 99 per cent of that in 1920, the record year. Statistics for the year 1921, up to the present time, were based mainly on reports of producers but in part on estimates. These estimates, however, were found to be only about 0.6 per cent lower than the final production figures.

Department of Commerce statistics show exports of hydraulic cement from the United States in 1921, at 1,181,014 bbl., valued at $4,276,986, or $3.62 per bbl., as compared with 2,985,807 bbl., valued at $10,045,369, or $3.36 per bbl., in 1920. The exports went principally to the West Indies, South America, Mexico and Central America. Imports in 1921 were 122,322 bbl., valued at $388,842 or $3.18 per bbl. as compared with 524,604 bbl., valued at $1,254,729 or $2.39 per bbl., in 1920.

Total production for the entire country during 1921, reached 98,842,049 bbl., 81.5 per cent of which were burned with coal as fuel; 10.2 per cent using crude oil; 5.6 per cent with both coal and crude oil and 2.7 using oil, coal and gas.

Pennsylvania held the lead, during 1921, with a total output of 27,628,5[illegible] bbl., from twenty-two mills.

Bids Wanted on Big Filtration Job

Proposals will be opened, on Dec. 1 1922, for a 10,500,000 gal. filtration plant; a 10,500,800 gal. concrete reservoir; c. i. pipe and castings, at the office of M. Rivera Ferrer, Commissioner of Public Works, San Juan, Porto Rico.

Weekly Construction Market

THIS limited price list is published weekly for the purpose of giving current prices on the principal construction materials, and of noting important price changes on the less important materials. Moreover, only the chief cities are quoted.

Valuable suggestions on costs of work can be had by noting actual biddings as reported in our Construction News section.

The first issue of each month carries complete quotations for all construction materials and for the important cities. The last complete list will be found in the issue of October 5; the next, on November 2.

Steel Products:	New York	Atlanta	Dallas	Chicago	Minneapolis	Denver	San Francisco	Seattle	Montreal
Structural shapes, 100 lb	$3.14	$3.95	$4.20	$2.90	$3.15	+$3.85	$3.25	+$3.80	$3.75
Structural rivets, 100 lb	3.85	4.60	6.00	3.35	4.00	4.80	4.50	5.00	6.50
Reinforcing bars, ¾ in. up, 100 lb	3.04	3.85	4.00	2.80	3.05	3.85	3.00	+3.80	3.25
Steel pipe, black, 2½ to 6 in. lap, discount	+54%	61.15%	45%	59½%	58.9-5%	+41%	47.9%	45%	30.00
Cast-iron pipe, 6 in. and over, ton	55.30	51.00	51.50	48.70	55.50	63.00	51.00	54.00	55.00
Concreting Material:									
Cement without bags, bbl	2.60	2.54	2.25	2.20	2.39	2.85	2.71	2.90	2.88
Gravel, ¾ in., cu.yd	1.75	2.00	2.25	2.00	1.75	1.75	2.25	1.00	1.50
Sand, cu.yd	1.00	1.35	2.25	2.00	1.00	0.75	1.50	1.00	1.25
Crushed stone, ¾ in., cu.yd	1.75	1.90	1.65	1.60	2.25	3.50	2.25	3.00	1.90
Miscellaneous:									
Pine, 3x12 to 12x12, 20 ft. and under, M.ft	59.00	42.00	40.00	51.00	41.00	39.75	35.00	24.50	50.00
Lime, finishing, hydrated, ton	15.80@16.17	23.00	25.00	18.00	25.50	24.00	22.00	24.00	21.00
Lime common, lump, per bbl	2.75@3.14½	1.85	2.50	1.40	1.40	2.70	1.75	2.80	11.00
Common brick, delivered, 1,000	—16.90@18.55	12.00	10.90	11.00	18@19	12.00	15.00	14.00	16.00
Hollow building tile, 4x12x12, per block	Not used	.0776	.115	.1101	.09	.065	....	.11	.08@.16
Hollow partition tile 4x12x12, per block	.1230	.0776	.115	.0808	....	.065	.108	.11	....
Linseed oil, raw, 5 bbl. lots, gal	.93	.97	1.13	—.94	+1.00	1.08	1.04	.86	1.06
Common Labor:									
Common labor, union, hour	.60	.35	.....	.....	.....	.50@.55	.56¼	.50@.60	.....
Common labor, non-union, hour	.44@.60	.30	.25	.72½	.35@.50	.35@.50	.47½@.50	....	.35

Explanation of Prices—Prices are to contractors in carload lots unless other quantities are specified. Increases or decreases from previous quotations are indicated by + or — signs. For steel pipe, the prevailing discount from list price is given: 45-5% means a discount of 45 and 5 per cent. Charge is 15c. per 100 lb. for cutting reinforced steel into 2-ft. lengths or over.

New York quotations delivered, except sand, gravel and crushed stone, alongside dock; common lump lime, in 280-lb. bbl. net, and hydrated lime f.o.b. cars; tile "on trucks"; linseed oil and cast-iron pipe f.o.b. Cement and concrete laborers' rate, 81¼c.; pick and shovel men, 60c. per hr.

Chicago quotes hydrated lime in 50-lb. bags; common lump lime per 180-lb. net. Lumber delivered on job.

Minneapolis quotes on fir instead of pine. Brick, sand and hollow tile delivered. Cement on cars. Gravel and crushed stone quoted at pit. We quote on brown lime per 180-lb. net; white is $1.55 for Kelly Island and $1.45 for Sheboygan. Common labor not organized.

Denver quotes on fir instead of pine. Cement "on tracks"; gravel and sand at pit; stone on cars; lime, brick, hollow tile and lumber on job. Tile price is at warehouse. Linseed oil, delivered, in wooden bbl. Common lump lime per 180-lb. net.

Atlanta quotes sand, stone and gravel per ton instead of cu.yd. Common lump lime per 180-lb. net.

Dallas quotes lime per 180-lb. bbl. Steel, cement, cast-iron pipe and crushed stone f.o.b. cars, other materials delivered.

San Francisco quotes on Heath tile, 5½ x 8 x 11½. Prices are all f.o.b. warehouses except C. I. pipe, which is mill price plus freight to railway depot at any terminal. Common lump lime per 180-lb. net. Lumber prices are to dealers in yards at San Francisco, for No. 1 fir common.

Seattle quotes on Douglas fir (delivered) instead of pine. Lump finishing lime per 180-lb. net. Hollow building tile delivered. Hydrated lime in paper sacks. Sand and gravel at bunkers.

Montreal quotes on Douglas fir instead of pine. Sand, stone, gravel and lump lime per ton. Cement, lime and tile are delivered; sand, gravel and stone on siding; brick f.o.b. plant; steel and pipe at warehouse. Hollow tile per ft. Cement price is in Canadian funds (the Canadian dollar stands at par.) Bag charge is 80c. per bbl. Discount of 10c. per bbl. for payment within 20 days from date of shipment. Steel pipe per 100 ft. net; 2½-in., $30; 6-in., $110.

Changes Since Last Week

Steel structurals up 5c. per 100 lb. in Denver and Seattle warehouses despite the general downward trend of mill quotations. A slightly easier fuel situation reflected in lower pig-iron prices. Structural shapes and reinforcing bars, however, are quoted at an average price of $2 per 100 lb., Pittsburgh, with small tonnages as high as $2.10@$2.15.

Discounts reduced two points on both black and galvanized wrought-steel pipe, on new Pittsburgh basing card of Oct. 19. Rise immediately reflected in lowering of warehouse discounts in New York and Denver.

Downward tendency seen in prices of kiln products, consequent to improvement in coal situation and seasonal falling off in demand. Common brick quoted at $14@$15.50 as against $15 @$16 per M. alongside dock, New York; Kelly Is. lime, $1.55 as compared with $1.70 and Sheboygan, $1.45, down from $1.55 per bbl. (180-lb. net) f.o.b., Minneapolis.

Linseed oil declined 3c. in Chicago, during week and rose 2c. per gal. in Minneapolis; prices stable elsewhere.

Lumber prices unchanged despite hampering by car shortages, of logging and lumber mill operations. Situation becoming serious in the Northwest and unless soon relieved, will result in the closing down of many logging camps.

Pine lumber shipments from mill to New York City, however, now accomplished in five and six weeks as against seven to nine weeks, one month ago.